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## METASTASES OF THE BONE IN PRIMARY CARCINOMA OF THE LUNG

A REVIEW OF SO-CALLED ENDOTHELIOMAS OF THE BONES \*

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AND  
EDWIN W. RYERSON, M.D.

CHICAGO

Some phases of the study of malignant tumors have been more actively prosecuted during recent years than others, for example, the experimental production of tumors in animals with tar and allied substances, the influence of heredity and of racial susceptibility and the statistics of tumor incidence. Malignant tumors of the bones and primary carcinomas of the lungs have also received a large amount of attention. The opportunity to secure complete postmortem examinations of the bodies of four patients, who died with primary tumors of the lungs and secondary growths in one or more bones, has led to a review of the literature and to some suggestions which, it is hoped, may be useful. We are indebted to Dr. George Dick for permission to include an account of the clinical features of the illness of the first of these patients, and to Dr. Carl Apfelbach for his record of the postmortem examination.

### REPORT OF CASES

CASE 1.—*History*—E. V., a woman, aged 76, entered the Presbyterian Hospital, April 14, 1927, and died twenty-four hours later. Three weeks before admission she had had a sudden severe pain in the right shoulder followed by partial loss of function in the right arm. She had suffered from a cough and shortness of breath for several months. The sputum was free from blood. Weakness had been marked for the past three months. The cervical lymph glands were enlarged on both sides. There was a pathologic fracture of the right clavicle. The right side of the chest was fixed and flat on percussion. On admission the leukocyte count was 32,500. Only the pertinent parts of the postmortem records are reported. *Anatomic Diagnosis*—The following diagnosis was made: carcinoma of the lower end of the trachea and right main bronchus; metastatic carcinomas of the mediastinal, cervical and subclavian lymph glands, and of the right clavicle.

\*From the Henry Baird Favill Laboratory of St. Luke's Hospital, Chicago.  
\*Dr. E. R. LeCount has written the histologic descriptions of these tumors and aided greatly in the preparation of this manuscript. He insisted at all times when only surgical tissues were available, that the tumors were carcinoma and not endothelioma of the bones.

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deeper masses lying in collections roughly parallel to the surface. Covering the elevation was a thin layer of epithelium, stratified by metaplasia, continuous with the deeper masses, and with many scattered places where the superficial cells were separated by artefacts. The deeper layers of the normal columnar epithelium were still attached to the surface outside the elevation where there had been no metaplasia, and all about the elevation there were rounded solid masses of epithelium in the lymph channels of the most superficial layers of the mucosa, the external cells of such masses being more deeply stained and smaller. In a section of the growth in the right clavicle, 10 by 15 mm, the masses of tumor cells were mainly at one of the two long margins where there was periosteum irregularly thickened and entirely grown through by tumor in two



Fig 1—Photomicrograph of 4 mm of the mucosa of bronchogenic carcinoma number 1, including one of the warty growths. *A* indicates the fibrous tissue between the ends of a cartilage ring. *B* cartilage. *C* the place where the epithelium is but slightly changed, *D*, a mass of tumor cells in a deep lymph channel, and *E*, discrete masses of tumor cells.

places. Centrally, the marrow was necrotic with a great deal of hemorrhagic. The average collection numbered from 30 to 40 large tumor cells in close contact and with faintly marked intercellular bridges between some of them. There was no suggestion of keratohyaline production.

In the metastatic growths of the liver (fig 2) and of the suprarenal, and in the large growths in the lower lobe of the right lung, in the trachea and bronchial and cervical lymph glands and in the nodules in the pleura the characteristics of the tumor cells and of their aggregations were almost similar. In

lungs, parietal and visceral pleurae, liver, left suprarenal gland and diaphragm, recent thrombosis of the right jugular vein, left hemothorax, right hydrothorax, recent infarcts of the spleen, acute emaciation, senility and generalized senile arteriosclerosis

At the postmortem examination nothing of note was found externally. On the under surface of the right side of the diaphragm the examiner found several flat hard masses from 5 to 6 mm in diameter. The left pleural cavity contained 490 Gm of a bloody fluid and the right 1,535 Gm of a brown, slightly turbid fluid. The lower front margin of the upper lobe of the right lung was bound to the wall of the chest by fibrous adhesions. In the back part of the thorax there was a mass of soft gray tissue in the parietal and visceral pleura about as large as the palm of one hand. There were similar masses in the parietal and visceral pleura of the left lung. Those on the left side covered about one sixth or one seventh of the pleural surface. The right lung was bound to the diaphragm by fibrous tissue in which were many gray-red nodules. In the upper half of the right lower lobe was a hard tumor 9 cm in diameter. The pleura over this was intact and lighter gray than the surrounding tissues. Surfaces made by cutting this large mass were uniformly gray and were mottled with black spots and pinpoint-sized yellow regions. The lungs together weighed 1,365 Gm. The thyroid gland weighed 70 Gm.

Above the left clavicle were hard enlarged lymph glands which were made up of gray tissue. There were similar masses of gray tissue in the anterior mediastinum and in both lower cervical regions, most marked on the right side. The right jugular vein passed in front of a tumor mass 5.5 by 4.5 cm in its largest dimensions. The common carotid artery was medial. The mass covered the right brachial plexus. There was another mass below the level of the right clavicle, high in the mediastinum on the right side, compressing the innominate artery and pushing it over to the midline. It was in front and to the right of the trachea.

In the lower end of the trachea in the front wall were superficial elevations in the mucosa, varying in size from that of a pinpoint to 2 mm in diameter, covering a place equivalent to about 4 sq cm. There were similar elevations in the right main bronchus. The right clavicle was broken 10 cm from the sternal end. In the shaft close to the fracture the marrow varied from gray-red to red. There was no change in the cancellous portion of the bone 3 mm away from the break.

The left suprarenal gland was replaced by a mass 9 cm long. At the lower pole was a portion of gland 1 cm long with the cortex unchanged and the medulla replaced by gray tissue. In the upper portion the tissue was soft and putty-like over a region 7.5 by 3.5 by 3 cm. The tissue consisted chiefly of light gray-yellow masses surrounded by gray fibrous tissue. The left suprarenal gland weighed 7.5 Gm. In the posterior surface of the right lobe of the liver, close to the lateral margin were three gray masses like those in the pleural surface of the lungs. The largest of these was 3 cm in diameter. There was no gross change in the heart, spleen, kidneys, pancreas, uterus, ovaries, bowel or stomach, except as mentioned elsewhere.

*Histology*—In sections containing a segment of one of the elevations 4 mm across (fig 1) in the lining of the right main bronchus, the mucous membrane was twice as thick as on either side, largely continuous stratified epithelium superficially, with scattered islands of similar epithelium in its deeper half. The more superficial epithelium was in masses with their long axes at right angles, the



the lung and lymph glands, there were large regions of necrosis. In many of these secondary growths, there were occasional huge epithelial cells with large nuclei (fig 2 *A*). The sections through the clot in the right jugular vein did not contain any tumor cells, and in those of the infarct in the spleen there was simply anemic necrosis without tumor.

Noteworthy in the foregoing account are the development of the tumor at such an advanced age, the pavement-like character of the tumor cells and mosaic appearance of their grouping, the absence of keratohyaline, the pathologic fracture of the right clavicle and the assurance regarding the location of the primary tumor. Warty growths in

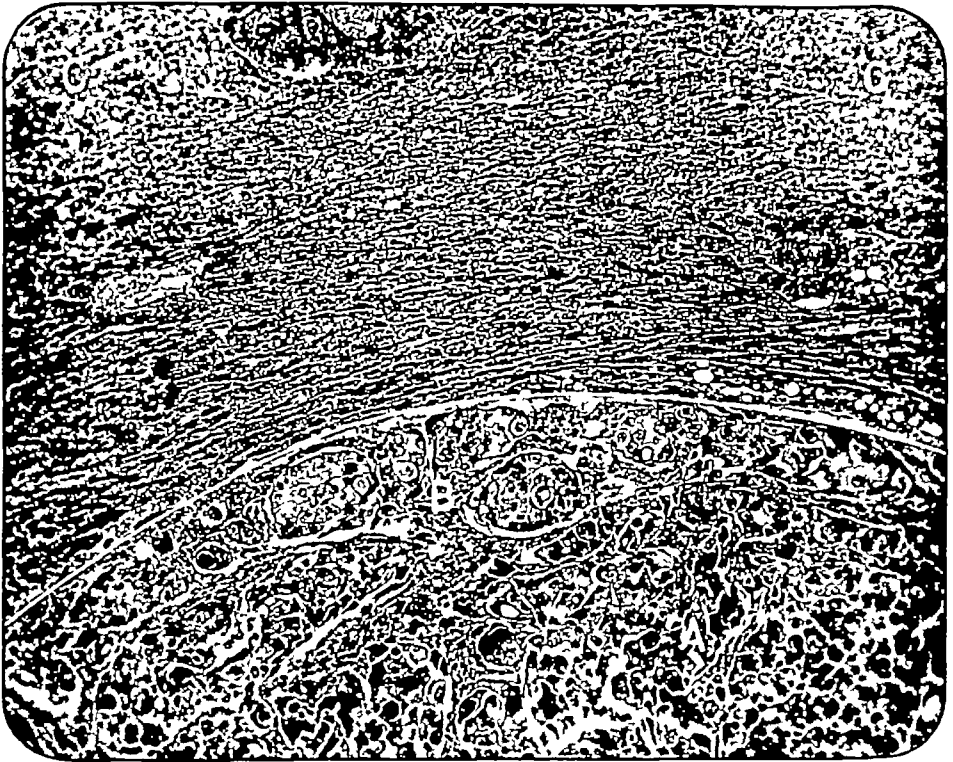


Fig 2—Photomicrograph of a carcinoma metastasis of the liver (tumor number 1), containing masses of tumor cells with a suggestion of keratohyaline metamorphosis (*A*). *B* indicates lymphocyte exudate, and *C*, compressed liver cells.

the lining of the large air passages, or grossly obvious, had thickenings of the mucous membrane are perhaps more valuable than all other manifestations in interpreting what has taken place. For many years, these alterations, accompanied in some tumors with a greater narrowing of the channel, and in some with superficial ulceration, have determined the primary nature of the tumor in the lining of large air passages.

The second of these tumors was in a patient in the service of Dr R W McNealy at St Luke's Hospital, to whom we are indebted for the following clinical history:

**CASE 2—History**—W S, a man, aged 28, entered St Luke's Hospital on Nov 23, 1926, complaining of pain in the chest and in the left side for one week, and a progressive loss of weight for a month. He had a slightly productive cough. A tumor the size of a large orange on the left side at the level of the anterior superior spine was attached to and in the innominate bone there. This was supposed to have followed an injury. The temperature ranged between 99 and 100 F, rising to 104 on the day of death. The leukocyte count was 10,000, there was a slight diminution in the number of red blood cells of which there were 4,000,000. The Wassermann test of the blood was negative. Roentgen-ray examination revealed a dense circular shadow in the upper part of the chest on the left side. The iliac part of the left innominate bone was partly destroyed, and the eighth thoracic vertebra was narrowed. A tentative diagnosis was made of tuberculosis or growth secondary to a tumor of the left innominate bone. The patient died on Dec 9, 1926.

**Anatomic Diagnosis**—The following diagnosis was made: primary carcinoma of the left lung, carcinoma extension into the hilum tissues of the left lung, bilateral multiple carcinoma metastases of the kidneys, multiple metastatic carcinomas of the left suprarenal gland, left perirenal fat tissue, left iliac bone, seventh thoracic intervertebral disk, eleventh thoracic vertebra and right ninth rib, marked emaciation, slight acute bronchitis, small epicardial hemorrhages, cloudy swelling of the myocardium and the parenchymatous organs, hyperemia of the urinary bladder, small bowel and rectum, bilateral petechial hemorrhages of the renal pelvis and ureters, hyperplasia of the thyroid gland and of the cervical, axillary, inguinal, femoral, mesenteric and biliary lymph glands, left fibrous pleuritis, marked osteoporosis of the ribs, slight hyperemia of the esophagus and subconjunctival ecchymosis of the left eye.

The right lung was collapsed and flaccid. The base of the lower lobe was adherent to the upper surface of the diaphragm by fibrous tissue. There were fibrous adhesions between the apex of the left lung and the wall of the chest and in the posterior part of the left pleural cavity were a few cubic centimeters of thin yellow fluid. The lymph glands at the bifurcation of the trachea and main bronchi were black with coal dust and formed a mass 4 by 2.5 by 1 cm. On the left side of the trachea extending into the hilum, was a firm mass, 7 by 4 by 2 cm, made up of lymph glands up to 2.5 cm in diameter, with yellow soft tumor tissue occupying one half or more of their substance. The lining of the trachea was gray-pink. The right lung weighed 380 Gm, the left, 580 Gm. The lining of the main bronchus and its first branches to the lower lobe of the left lung was normally wrinkled in longitudinal folds. So also was that of a large branch to the lower part of the upper lobe of the left lung except the main branch to the apex, which had longitudinally arranged folds for a length of 3 cm and then merged into a mass of firm but friable tissue gray-white mixed with black and 6 cm in diameter. The gray portions were studded with yellow pinpoint regions. The lumen of the bronchus was occluded, and at the beginning a little of the cartilage of the wall was embedded in the soft gray tissue. This mass extended into the hilum of the lung and merged into the tumor referred to on the left side of the trachea. Elsewhere the left lung was crepitant the pleura smooth and glistening and without tumor masses. The right lung was unchanged. The right kidney weighed 150 Gm. Its capsule stripped easily for 1 cm, the gray smooth surface, beneath which were several gray secondary tumors 1 to 1 to 25 mm in diameter, others were deeper in the substance of the kidney.

cortical striations were moderately diminished and the glomerular tufts scarcely visible. The little tumors were gray inside. The left kidney weighed 195 Gm. In the fat close to its dorsal surface and convex margin was a firm tumor 12 mm in diameter, pearly white inside. In the lower pole was a nodule of white and faintly yellow tumor tissue 28 by 22 by 28 mm, extending through the cortex into a renal pyramid. On the ventral surface near the convex margin embedded deeply in the cortex was another 1 cm in diameter. In other respects this kidney was like the right.

In the cortex of the upper pole of the left suprarenal gland was a gray tumor nodule 3 mm in diameter. In the fat at the upper pole were two others, one 3 and the other 6 mm in diameter. There was a moderate diminution of the yellow substance of the cortex. The lining of the suprarenal vein was smooth throughout.

In the outer part of the upper margin of the left innominate bone and its ala was a tumor 13 cm along the iliac crest, 5 cm wide and extending into the ala 5.5 cm. It was surrounded by a fibrous capsule and was very soft. The bone was destroyed for a depth of 5.5 cm, but just beneath the capsule were spicules of bone. The tissue was gray to yellow, except for minute places that contained a yellow fluid. Approximately 20 per cent of surfaces made by cutting consisted of these necrotic regions. The muscle about the bone seemed to be pushed away rather than invaded by tumor tissue.

The seventh thoracic intervertebral disk was thickened by a mass of gray-pink, moderately firm tissue which projected against the dura of the cord. This thickened tissue was roughly wedge-shaped, the widest place being along the cord, where it was 1.8 cm, from here it tapered forward. The intervertebral disk left white surfaces when lifted from the bodies of the seventh and eighth thoracic vertebrae, but in the cartilage were fine spicules of bone.

In the ninth rib, 3 cm from the anterior axillary line, was an erosion of the bone and a replacement by gray-white tissue, forming a nodule 3 cm long, 2 cm wide and 1.6 cm thick. On the left side in the body of the eleventh thoracic vertebra, just above the margin of the twelfth rib, was a pink-gray mass 2 cm long, measured along the spinal column, 1.5 cm wide and projecting about 5 mm. This extended about 5 mm into the substance of the bone, and forward about the same distance. The bone was eroded and replaced by a soft gray tissue. There were no gross changes in the heart, liver, spleen, pancreas, gall-bladder, stomach, intestines, trachea, esophagus, large blood vessels, thyroid gland, testes, epididymides, prostate gland, seminal vesicles, appendix vermiformis, brain or leptomeninges, except as stated.

*Histology*—In sections from the wall of the bronchus in the upper lobe of the left lung from which the tumor radiated,<sup>1</sup> from many parts of the tumor farther out in the lung, and from the various metastatic growths in the kidney, suprarenal gland, eleventh rib and left innominate bone, the tumor cells were alike, tall cylindric cells arranged in tubules or solid cords (fig. 3), much like the formations in cylindric cell carcinomas of the colon, but without much production of mucin. They were undoubtedly from the glands in the mucous membrane of the bronchus, from which the tumor grew so symmetrically. In the nodules in the kidney the tumor cells were more compact, and in some of the sections from the tumor of the lung there was a large amount of necrosis.

1 Kaufmann. Lehrbuch der speziellen pathologischen Anatomie 1 312, 1911 (The author refers to the bronchus from which the tumor arises as a pedicle for the tumor.)

The short duration of the illness, the discovery of a tumor in the thorax, the suspicion that the tumor of the innominate bone was primary and followed an injury, and the character of the tumor a cylindric cell carcinoma, are the conspicuous features of this second bronchiogenic tumor.

The next tumor, reported with permission of Dr. H. B. Thomas, also from St. Luke's Hospital, was of much longer duration and remained unrecognized until shortly before the patient's death. It also arose from glands in the mucous lining of a bronchus.



Fig. 3—Photomicrograph of the metastatic tumor of the left innominate bone (tumor number 2). *A* indicates collagen fibers (periosteum).

CASE 3—*History*—I. G., a man aged 38, was admitted to the hospital on May 21, 1925, complaining of pain in the right forearm, index and middle fingers which began insidiously about one year before admission. During February, 1925, a graft of fascia lata was transplanted about the right ulnar nerve. The right forearm was swollen, from the elbow to the wrist and fingers with induration about the elbow and marked tenderness. The temperature was 98.4 F. the pulse rate was 88, the respirations, 18. Viscosity and osteomyelitis of the right radius and ulna were diagnosed. Necrotic bone was removed June 1, 1925. During the spondylitis. Microscopically the tissues contained regions of chronic inflammation and fibrous tissue replacement of the fat in the marrow spaces. There was no change in the hemoglobin or in the number of cells in the blood. White blood tests of the blood and spinal fluid were negative. No organisms were found.

in the pus, and nothing grew from it on culture medium. On July 26, 1925, the elbow was incompletely ankylosed at 90 degrees, swollen, tender and red, but the patient was not acutely ill. Examination of material from the head of the ulna and radius removed at operation Aug. 13, 1925, indicated simply a low grade suppurative osteitis. The symptoms persisted. The urine never contained more than a trace of albumin. The Wassermann tests continued to be negative, the white cell count averaged about 9,800, the temperature was 98 F, the pulse rate, 104, and respirations, 22. By Oct. 14, 1925, the entire arm was swollen again and was exceedingly painful. There were palpable lymph glands in the axilla, and five days later the arm was blue and edematous. It was amputated at the distal end of the proximal third of the humerus on October 24, and the

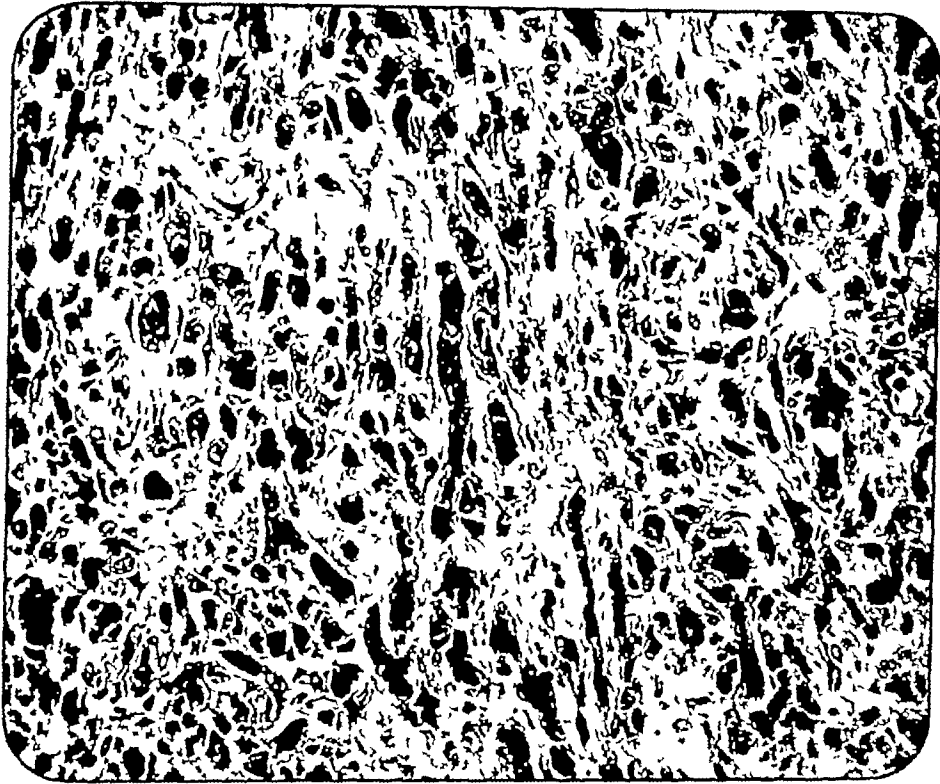


Fig 4—Photomicrograph of tumor cells discovered in tissues following surgical amputation of the arm (tumor number 3). The rows of epithelial cells are arranged in scar tissue like any so-called scirrhous carcinoma originating in a gland. At several clinical conferences, and by some pathologists to whom microscopic preparations were submitted, this tumor was diagnosed endothelioma.

patient was discharged on November 7, with a diagnosis of chronic periostitis of the bones of the right arm. Other diagnoses considered were hypertrophic osteoarthropathy of Marie, proliferating ossifying periostitis, condensing osteomyelitis and secondary hypertrophic osteitis.

*Histology*—In sections from a number of places in and around a callus where the several operations were made about the elbow, there was a great deal of scar tissue in the soft tissues enclosing irregular cells in poorly defined rows (fig 4). In many places the scar tissue greatly exceeded the cells, which were isolated

Some were necrotic, many were multinucleated, and some contained blood pigment. It was evident that cicatrization had hampered their growth. Prolonged search was necessary to find any indication of mitosis. In the section containing bone a great majority of the cells were single or in groups of two or three and separated from the stroma by small empty spaces. In larger groups however there was a faint but definite grouping simulating tubules. These conditions led to the conclusion that the cells were epithelial, and that the disease was caused by carcinoma dissemination. A primary pulmonary carcinoma was suspected. The patient was again thoroughly examined following this report, but the primary tumor was not found. He was readmitted to the hospital on Dec. 1, 1925 with pain in the right side and back for twenty-eight days, pain in the right side of the chest, more noticeable on inspiration and expiration, pain in the left wrist, both ankles and knees, and swelling of the ankles, knees and hand. The pain was continuous but never severe, and had been present since the amputation. The left hand was swollen and hard, but not edematous. The ulna and radius were rough, but not thickened. The feet were swollen and there was decreased resonance with fine rales over both apices. There was slight tenderness on pressure in the left sixth, seventh and eighth interspaces near the spine. Roentgen-ray examination showed a rarefaction and regions of condensation of the clavicles especially of the peristernum. The left half of the diaphragm was elevated and there was a left diaphragmatic pleuritis, but no tumors. The white cell count gradually increased to 14,200 on Dec. 26, 1925. The basal metabolic rate increased from plus 9.6 on Jan. 19, 1925, to plus 39.2 on Dec. 4, 1925. On December 2, there was selective dullness over both bases and tenderness near the spine of the sixth, seventh and eighth vertebrae. There was no indication of any organic change in the central nervous system, and no evidence of tumor of the prostate gland. On December 18, a hypostatic pneumonia was found, and the temperature rose to 102 F., the pulse rate was 120 and respiration 44. The patient died on Jan. 1, 1926.

*Anatomic Diagnosis*—The following diagnosis was made: small primary carcinoma of the left bronchus, multiple metastatic carcinomas of the pleura, tracheobronchial and periaortic lymph glands, lungs, diaphragm and bone. Marked bilateral serofibrinous pleuritis, acute catarrhal tracheitis and bronchitis. Fibrinous changes in the leaflets of the mitral and aortic valves, moderate hyperplasia of the spleen, chronic diffuse nephritis, hyperemia of the urinary bladder and rectum, generalized senile arteriosclerosis, healing impaction stump of the right arm, old laparotomy scar, appendectomy scar of the cecum, decubital ulcer of the sacrum, emaciation and an old fibrous scar of the liver. The costal cartilages cut with increased resistance. In the right pleural cavity was about 1 liter of a yellow turbid fluid in the left a slightly smaller amount of a similar fluid. The right lung was irregularly adherent to the parietal pleura as was also the left near the base. The right lung weighed 500 Gm, the left 500. The surfaces of the

- 2 Delbet, Pierre, and Mendoro. Epitheliome a cellule independante. Les Cancers du Sein, Paris, Masson & Compagny, 1927 p. 169.
  - 3 In an article now in press. Unusual Bone Carcinoma. Cited by Henry B. Thomas. Ed. in H. and E. Blaine the interesting conditions found by the author.
- tions are described. They were reported by Dr. Blaine in 1927.
- Section on Radiology at the meeting of the American Medical Association, Washington, D. C.

right lung were studded with raised, gray masses, from 1 mm to 1 cm in diameter. There were similar masses from 1 to 5 mm in diameter in the pleura of the left lung. The lower lobes of the lungs were not crepitant. Surfaces made by cutting were red-brown, smooth and moist. The peribronchial lymph glands were hard, small and black, with regions of white-gray tissue. The left parietal pleura was red-yellow-brown, studded with firm, raised, white glazed plaques, from 1 to 10 mm in diameter, many of them confluent, the majority linear, parallel to the ribs and averaging 5 mm in width. The right parietal pleura was similar to the left.

The lining of the trachea and main bronchi was very red and covered with a viscid yellow secretion. The tracheobronchial lymph glands were from 5 to 20 mm in diameter, firm and gray-black, and had gray-white regions inside.

On the abdominal surface of the diaphragm was one tumor nodule 5 mm in diameter. Another 10 by 13 mm was in the right lobe of the liver in front under the capsule. The liver weighed 1,820 Gm. A section of the duodenum at the ampulla of Vater was red-brown. The blood vessels were distended, and there were a few subserous gray-white nodules. The mucosa was red-brown, and there were a few submucous hemorrhages. There was no gross change of the heart, thyroid gland, esophagus, stomach, suprarenal glands, kidneys, urinary bladder, gallbladder, prostate gland, spleen, rectum, larynx, testes, epididymides, intestines, brain, pancreas or large blood vessels, except as already mentioned.

A section of the left tibia, 18 by 3.5 by 5 cm, was partially covered by muscle and areolar tissue. The periosteum was firmly adherent, and beneath the periosteum the bone was rough, and on cross-section there was a layer 1 mm thick which was distinctly demarcated from the enclosed cortex. The cortex was hard, the medulla, yellow and soft. The right clavicle was roughened anteriorly 1 cm from the sternoclavicular junction. The periosteum was firmly adherent, but slightly thickened. The underlying bone was smooth, except for the roughened regions mentioned, which were red and extended half the width of the bone. There was a roughened ridge on the anterior and superior surface of the left clavicle, extending 1.5 cm from the distal end of the bone to the middle. There was also a jagged, rough protuberance 1 cm in diameter, 2 cm from the sternocostal junction. The external surface of a piece of bone removed from the anterior crest of the right ilium was smooth and yellow-white. The periosteum was adherent, but not thickened. The cortex was rough hard and yellow-white. The medulla was red. The fifth right rib was smooth, varying from red-brown to gray-brown. The cortex was relatively normal to the amount of cancellous tissue. The cortex was yellow and hard, the medulla was soft and red. The right fourth rib was similar.

After fixation in formalin, the lungs were cut into parallel horizontal segments 1 cm thick and the following was noted. The left bronchus divided abruptly into a large branch to the lower lobe and another to the upper. That to the lower lobe again divided 1 cm from the first bifurcation into two branches, one with a large lumen (8 mm) toward the medial side, the other with a smaller (5 mm) more directly out to the left. The wall of the smaller was 4 mm thick, that of the larger, 2 mm where they arose. Beyond this bifurcation the channels of the branches of the bronchus with the smaller lumen were filled with coagulated mucus, and the thickness of its mucosa 1 cm beyond its origin was 5 mm. The surface of this thick lining was finely granular and warty as compared with that of the other bronchi which had a lining with small parallel longitudinal folds. The tissue of the lung supplied by the constricted bronchus was leathery and contained little air.

*Histology*—In sections through the primary growth in the left main bronchus there were places where the lining epithelium was unchanged. In others it had been mechanically dislodged into the channel. The epithelium in such fragments was unaltered, and the cells had a normal topographic relation to one another. Some such fragments were infiltrated with leukocytes. The tumor was in the tunica propria (fig 5), which was greatly thickened with scattered tumor cells with a leukocytic exudate which varied in amount and with huge lymph channels filled with tumor cells. From this region the tumor had extended into adjacent lymph glands and out through each lung in the lymph channels to the pleura forming there the flat masses noted at the postmortem examination. Extension along lymph channels in the tunica propria and outer coats of the bronchus of the left lung was extensive. Such channels in bronchioles with a lumen diameter

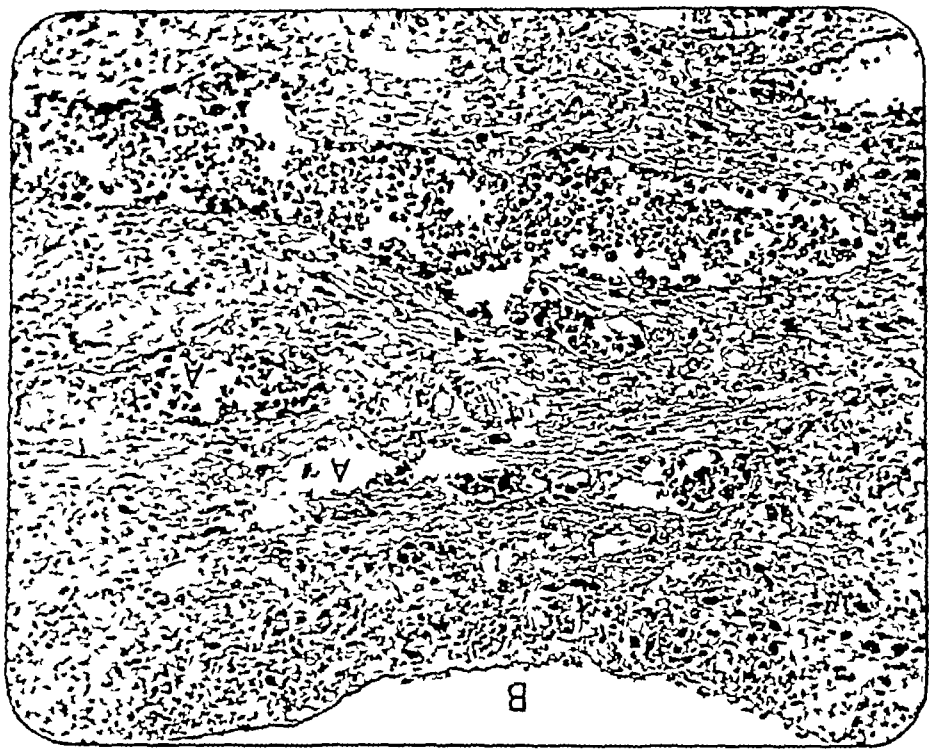


Fig 5—Photomicrograph of the primary carcinoma of the bronchus listed as number 3. The entire surface epithelium is absent. *A* indicates large submucosal lymph channels (veins?) filled with tumor cells. *B* the inner edge of the tunica propria basement membrane for the epithelial lining (absent from postmortem). *C* dislodgement and *C* scattered tumor cells in the tunica propria.

of from 1 to 2 mm were invaded (fig 6) as were the lymph channels. In many places a tissue reaction had resulted in scars or masses of fibroblasts in which all traces of the original lymph channels were lost. In such scars the tumor cells have been lost. Some such scars had developed in the lymph channels of interlobular septums (fig 7) and extended all the way across. Along their borders were small lymph vessels circular where cut off. These regions or inclusions were a common feature of the tumor where ever it had developed. The pleural effusion pathologic



(fig 8) The cicatrization resembled that frequently seen in some mammary carcinomas that grow slowly and deform the regions inhabited by the tumor

The failure to find any tumor in tissue removed at two operations was due, in part at least, to the amount of scar tissue caused by the tumor. This view is supported by the fact that microscopically tumor was absent in tissue from the periosteum and bone where, in a number of places, the outer parts of bones were found rough at the postmortem examination. The number of operations ending with amputation of one forearm, and the difficulty in finding the primary tumor after death are other impressive features of this third bronchiogenic carcinoma.

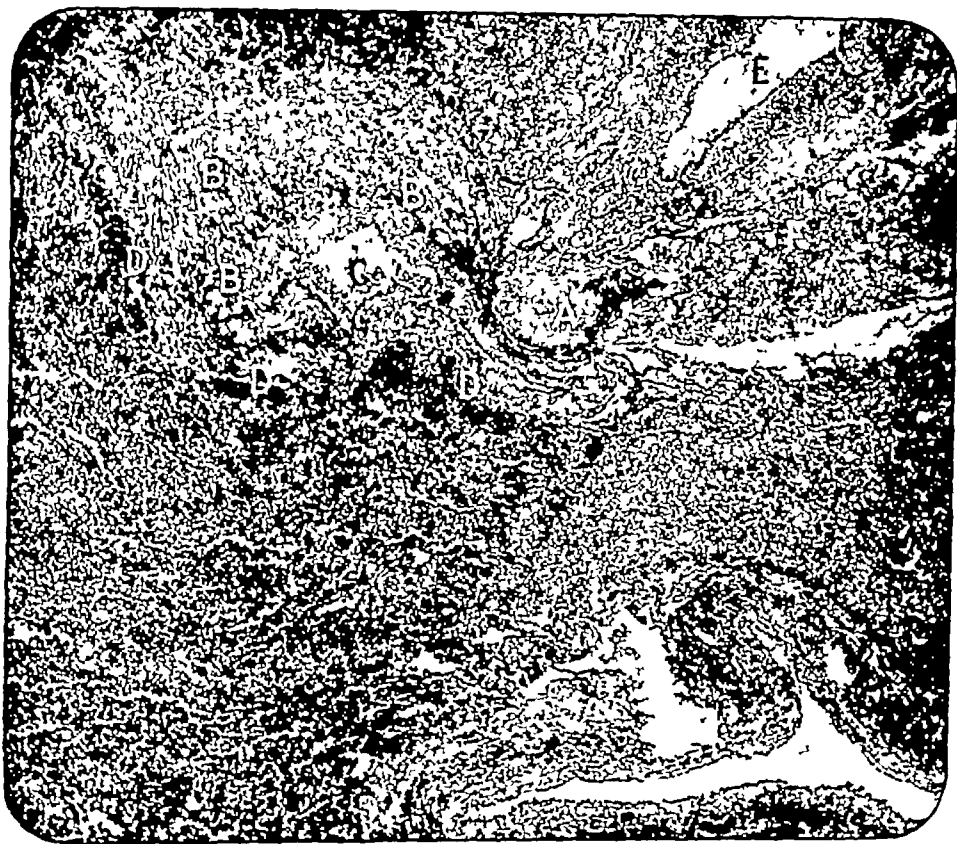


Fig 6—Photomicrograph of a portion (width 5 mm) of the primary bronchiogenic carcinoma listed as tumor number 3. *A* indicates cartilage, *B*, part of the wall of a pulmonary artery (*C*) with rows of tumor cells in scar tissue similar to figure 4, but in much less magnification, *D*, masses of tumor cells in perivascular lymph channels, *E*, the bronchus and *F*, the normal bronchial glands.

noma. Still another, to be considered later, is the diagnosis of endothelioma made on a number of occasions by pathologists and others at consultations and clinical conferences during the life of the patient.

The fourth bronchiogenic carcinoma was also pronounced an "endothelioma of the bone" by visiting pathologists and surgeons at clinics where the patient and his illness were reviewed. The youth of this fourth patient, a boy, aged 5, the son of a physician, is remarkable

CASE 4—*History*—The boy was admitted to St. Luke's Hospital on June 1, 1925 (to the service of E. W. R.), with pain and lameness of the left leg which began about April 1, 1925, two weeks after an injury of the leg. The pain had been severe, and the periosteum had been incised. One and one-half years before he had a severe attack of influenza followed by an acute otitis media which ruptured spontaneously. After that he had frequent acute infections. The upper and middle third of the left leg was slightly swollen and tender on pressure. There were no abnormal physical signs in the chest or abdomen at this time. The

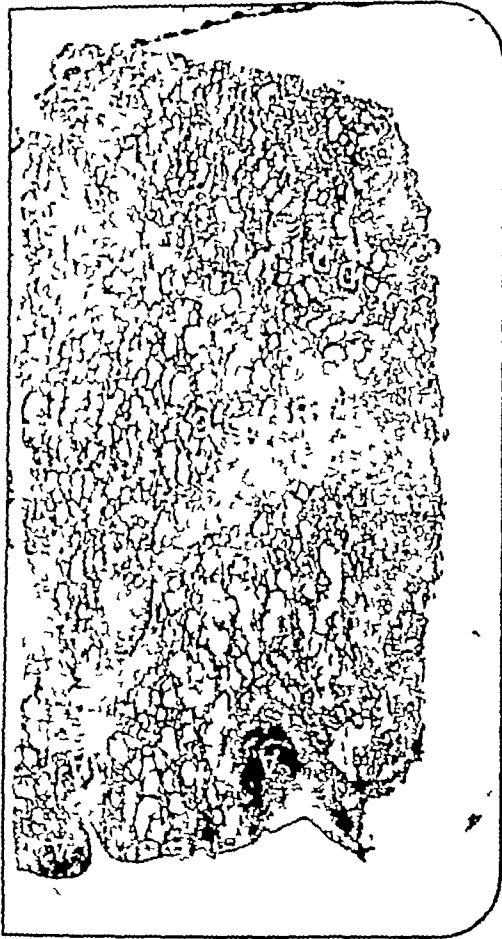


Fig 7—Photomicrograph (tumor number 3) of an entire section 7 b 13 mm, of the lung, X 8. A indicates subpleural lymph channels that were filled with tumor cells, B, a scarred septum with lymph channel (C) filled with tumor cells, and rows of tumor cells like those in figures 4 and 5 not visible with this magnification, and D, the perivascular lymph channel filled with tumor cells.

upper end of the tibia was drained and a little tissue removed. On the day of admission. Only necrotic tissue was found by microscopic examination. On October 14, the upper end of the tibia below the epiphysis was removed. A spindle-shaped enlargement about 4 cm in its maximum diameter was removed. The proximal end of the removed segment which was 15 cm long. The portion contained eroded bone and soft white tissue some of it necrotic.

*Histology*—The bone was thoroughly replaced by tumor cells in compartments which were generally oblong, the long diameters of which averaged about 0.2 mm, some were twice that length and many were much smaller. The partitions varied from a single capillary with a few fibroblasts to several such vessels, and were thin, delicate and loosely constructed. The cells in these compartments were fairly uniform in size, about as large as the epithelium of the convoluted tubule of the kidney, but with larger nuclei which possessed more chromatin. Generally, there was a narrow empty space between the cells and the stroma of the partitions, an artefact from fixation. The cells were arranged in the smaller compartments much like a tubule with the nuclei at the outer part of the cell toward the stroma and the cytoplasm toward the center (fig 9). The centers of such small groups of cells were therefore paler, the peripheries, dark.

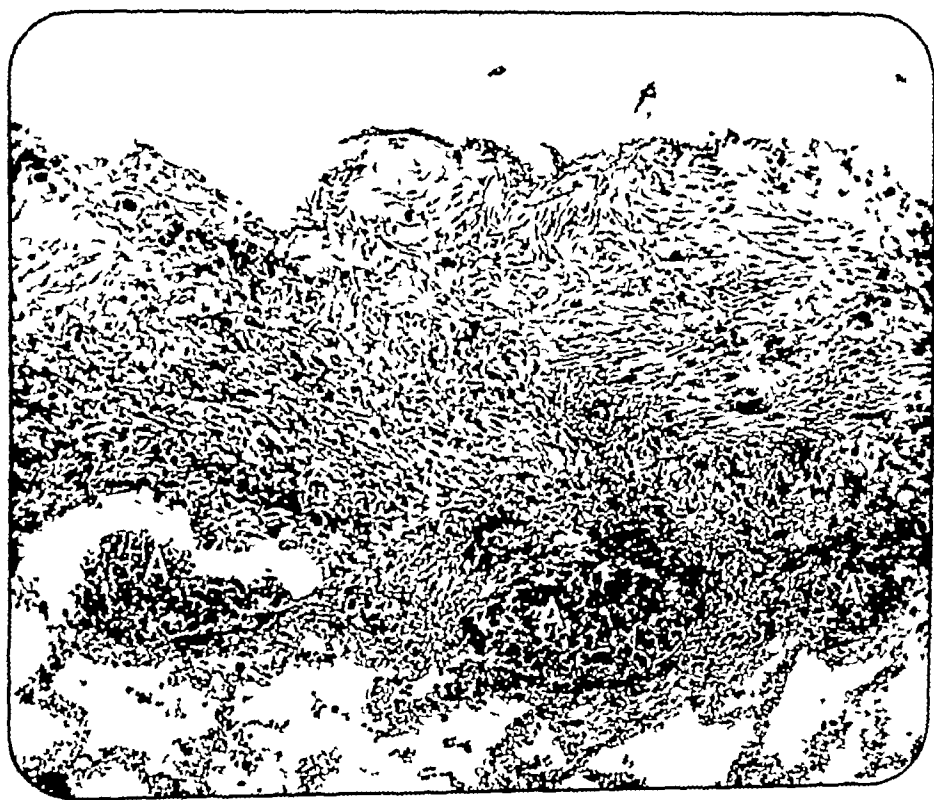


Fig 8—Photomicrograph of a pleural nodule to illustrate the cicatrization so conspicuous in this tumor everywhere (number 3). Compare with figure 4. A indicates the subpleural lymph channels containing tumor cells.

In spite of careful search in these central regions by appropriate staining methods, nothing resembling fibrils (neuroblastoma) was found. The aggregated central cytoplasm of a number of cells was without definite cell margins, it was fairly granular, definitely but slightly basophilic and slightly purple with hematoxylin. The nuclei occupied one half of the cells or a little more and were generally eccentric.

The cells were regarded as epithelium and the growth as a secondary carcinoma.<sup>3a</sup> A careful physical examination following this report failed to locate a visceral tumor.

<sup>3a</sup> Dr. Frank B. Mallory, pathologist at the Boston City Hospital, also concluded this tumor was carcinoma.

In August, 1926, symptoms of involvement of the lung appeared when a fluoroscopic examination was made, for the first time a large shadow was found in the lower lobe of the right lung. A recurrence of the tumor just below the left knee was noted. The patient died on Jan 3, 1927, at Tucson, Arizona, where the postmortem examination was made (E. F. H.).

*Anatomic Diagnosis*—The following diagnosis was made. Huge bronchiogenic carcinoma of the lower lobe of the right lung with extension into the mediastinum lymph glands, metastatic carcinoma of the left lung, the upper lobe of the right lung and thymic body, recurrent secondary tumor of the left tibia, bilateral serofibrous pleuritis, marked distention of the small veins of the esophagus, marked hyperemia of the esophagus, acute catarrhal bronchitis and tracheitis, slight

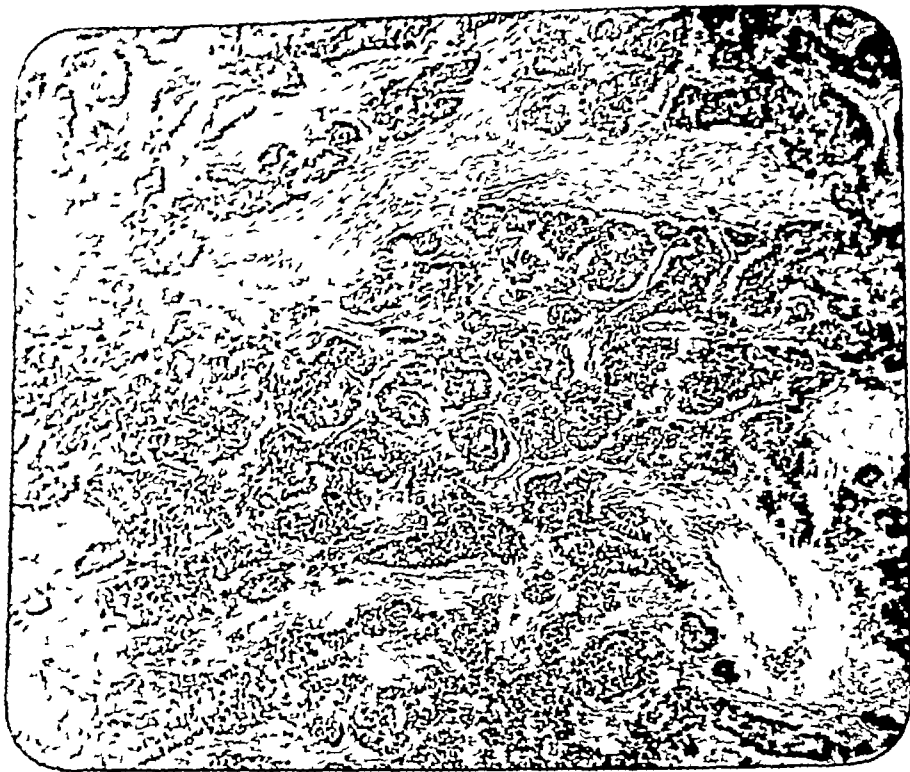


Fig 9—Photomicrograph of tissues in tibia removed surgically. This is a surface of about 4 sq mm. *A* indicates bone. The pattern of the cells is a feature of these groups (*B*).

hyperplasia of the biliary, mesenteric and iliac lymph glands and fatty changes of the liver and kidneys. Hyperemia of edema of the brain and leptomeninges, marked emaciation

skin of the left leg.

Just below the left patella was a nodular well-circumscribed

ward 10 cm, in its other dimensions 8 by 6 cm.

ing this mass was tense and from the upper end a small

extended to the patella. The tumor mass was white, soft

small linear or irregular yellow mottles and had a soft

tissues in this region. It had grown into the epiphysis and

the tibia markedly destroying the cortex and in the center of

cavity for a distance of 2 by 2 cm. There was no bone in the tumor tissue. The right pleural cavity contained from about 200 to 300 cc of a turbid fluid with a few thin flakes of fibrin, the left, about 50 cc. The right lung was firmly adherent to the mediastinum and diaphragm, but not to the wall of the chest. There were no adhesions on the left side between the lung and the wall of the chest. Close to the vertebral column, just above the tenth rib on the right side under the pleura, was a white nodule 5 by 5 by 2 mm. There was a large tumor mass lying in the posterior mediastinum, which was 14 cm long, 8 cm wide and 7 cm thick, and its lower edge was slightly to the left of the midline. It bulged backward so that the aorta arched over the back of the mass nearer the right side than the left. The position of the tumor corresponded to greatly enlarged lymph glands at the bifurcation of the trachea. The trachea was anterior to this mass, and the esophagus at the level of the bifurcation of the trachea was pushed to the left and lay laterally, along the margin of the tumor mass. There was a marked hyperemia of the lining of the esophagus and a marked distention of the vessels of the lining of the lower third, so that they stood out as coarse varicosities. Behind the pericardium and pushing it forward near the midline were two nodular masses, one above the other, the lower 20, the upper about 15 mm in diameter. The lining of the trachea and the left main bronchus to the first branches was pink-gray, unchanged and covered with a thin secretion. The tumor mass in the posterior mediastinum was continuous with another which had replaced most of the lower lobe of the right lung. It was 14 by 12.5 by 6 cm, gray lobulated tissue along the periphery and in the center porous like a fine sponge. The pulmonary vessels were unchanged. The right bronchus leading to the lower lobe passed directly into tumor tissue and could be followed for only about 3 cm. There was a little of the lower lobe along the upper border of this tumor. The lobe was pushed up by the tumor. There was a second tumor 3 by 3 by 2.5 cm in the small amount of remaining lung tissue at the upper edge of the lower lobe, and in the posterior portion of the right upper lobe was a third tumor 7 by 4.5 by 3 cm.

There were two masses of tumor tissue in the left lung, one near the front margin in the upper part of the upper lobe, 2 by 3 by 1.5 cm, the other near the base of the lower lobe, 1.2 by 1 by 1 cm. The lining of the bronchioles of the left lung was unchanged. Surfaces made by cutting these tumors resembled those in the main tumor in the lower lobe of the right lung. The tumor in the left knee had a similar appearance inside. There was no gross change of the heart, suprarenal glands, kidneys, liver, gallbladder, pancreas, stomach, intestines, urinary bladder, prostate, seminal vesicles, testes, epididymides, brain, cervical, iliac, axillary lymph glands or larynx indicative of tumor masses.

After fixation in formalin, the right lung was cut in a coronal plane through the root so as to divide the large tumor in the lower lobe and the other two smaller tumors through their largest diameters (fig 12). From one of the surfaces so made, forty-nine blocks with sizes convenient for sectioning in paraffin were taken by parallel transverse cuts and others longitudinal and at right angles to those across. The blocks, from 5 to 8 mm thick, were given numbers corresponding to those on a diagram the same size and shape as the tissue surfaces, with lines on the diagram matching the incisions of the tissue. In this manner, the location of sections studied was maintained. In a similar way, sections were examined from forty-three blocks from one of the two largest surfaces through the mediastinal tumor which it was possible to obtain with a single bisection.

*Histology*—In only a few of the many sections from the tumors of the lung was there a duplication of the minute structure in the tissue removed at the operation over a year before death. This was only in some of the sections from the lower lobe of the right lung, where the tumor structure was similar in all particulars, small epithelial tubules lying rather loosely in compartments with their nuclei out toward the stroma. In some sections there were masses of tumor cells in small lymph channels about bronchioles, about both pulmonary arteries and veins and in the minute lymph channels just beneath the pleura out and beyond the most peripheral pulmonary acini. In these lymph channels the tumor cells did not have any particular grouping. In the many sections of the large tumor of the mediastinum (thoroughly searched in vain for traces of a teratomatous tumor) and in those from other places in the lungs and recurrent tumor



Fig 10—Photomicrograph of the tissues of the tumor of the lung (no 4). The

condition prevailed throughout nearly all of the tumors in the lungs. There is a necrosis (quite regularly spaced) of the tumor cells where in multiplication they grew away from their blood supply. In sarcomas, new blood vessel production along with the tumor cells, as a rule, so that necrosis is infrequent. In the necrotic cells and B, zones of tumor cells separated by vascular fibrous stroma

of the tibia, there was a considerable deviation from that in the tibia examined

The original arrangement of single layers of epithelium for a (fig 9) was replaced by one with from fifteen to twenty cells in layers also in compartments and in many of these the cells a half inch far from their blood supply had undergone necrosis. In many of the tumors one dimension was much greater than the others as a

stalklike formation<sup>4</sup> occurred in many sections, stalks of vessel-bearing stroma on which the epithelium rested, and all about between such branching bands there was necrotic epithelium in varying amounts. This type of growth is common in the papillary tumors of the urinary bladder, renal pelvis and proliferating papillary cystic tumors of the ovary, especially those with considerable masses of tumor. Its best examples are met with in the secondary metastatic and recurrent growths of such tumors.

Because of the youth of the patient and the extreme rarity of a primary bronchiogenic carcinoma at his age, every effort was made to discover some evidence against the conclusion that the tumor originated in the lung tissues. Bone



Fig 11—Photograph of the tumor growth projecting into the lumen of the left bronchus (tumor number 2)

metastases have been reported<sup>5</sup> with neuroblastomas, but careful search has failed so far to demonstrate that the lung, mediastinal and bone tumors of this boy are of this nature. The contention may be made that the bone tumor was the primary growth, and that the lung and mediastinal tumors were secondary. The arguments against this and in favor of the conclusion that the primary tumor was in the lungs are (1) the gross appearance of the tumor in the lungs (fig 12), its close relation with and distribution around a large branch of the bronchus,

4 LeCount, E. R. The Genesis of Carcinoma of the Fallopian Tube in Hyperplastic Salpingitis, Report of a Case and a Table of Twenty-One reported Cases, *Bull. Johns Hopkins Hosp.* **12** 55, 1901.

5 Wahl, H. R. Neuroblastoma, *J. Med. Research* **30** 205, 1914.

the scalloped peripheral margin and the spongy consistency of its tissues. (2) the total absence of any attempt on the part of the tumor cells to produce bone cartilage or other bone tissue derivatives, including capillary-like channels such as occur in angioendotheliomas, with or without blood cells and in the tissues described by Smith<sup>6</sup> as "synoviomata." (3) the histologic structure in which the cells and the stroma were arranged, as in a papillary carcinoma with regions of necrosis along the peripheral portions where by multiplication the cells had grown away from their blood supply—a condition not noted in sarcoma. Finally (4) the fact that no known primary tumor of the bone has the tissue structure found in these tumors. Because of these features in spite of a careful search for evidence to the contrary, we are led to conclude that the tumor of the lung was primary and that the growth in the bone was a metastasis.



Fig. 12—Photograph to illustrate the extent of tumor growth in the rib lying in a coronal plane through the hilum (tumor number 4).

The outstanding features in this report are the youth of the patient (5 years at the onset of symptoms and 6 years at the time of death), the change in type of the tumor pattern from a tubular to papillary structure, the relatively long time during which the primary tumor of the lung remained without symptoms though when recognized it was large, the history of trauma to the leg, the involvement of several bones, the one bone by metastasis and the severe attack of influenza. The history before the symptoms of tumor growth in the leg (type 1).



## REVIEW OF THE LITERATURE

There are many<sup>7</sup> reports mentioning the increased frequency of carcinoma of the lungs, not a few ascribing a causal relation to the pandemic of influenza. The basis for this conclusion follows from studies<sup>8</sup> of the lungs in influenza which describe a hyperplasia of the bronchial epithelium or a metaplasia of the lining cells into pavement epithelium, like a precancerous growth. Meyer<sup>9</sup> has reported a bronchiogenic carcinoma, which he thinks was originated by an attack of influenza.

Of the 74 primary carcinomas of the lung reviewed by Passler,<sup>10</sup> secondary tumors were found in the bones with 12, Adler<sup>11</sup> mentions 57 with 374 primary carcinomas of the lung and the bronchus, Grove

7 Among these reports are

Payr, E. Extirpation eines grossen, primären Plattenepithelkrebses der Lunge, *Arch f klin Chr* **133** 700, 1924

Mathias, E., in Discussion on Teutschlaender, O., and Stahr, H. *Verhandl d deutsch path Gesellsch* **19** 190, 1923

Berblinger, W., in Discussion on Teutschlaender, O., and Stahr, H. *Verhandl d deutsch path Gesellsch* **19** 190, 1923, Die Zunahme des primären Lungenkrebses in den Jahren 1920-1924, *Klin Wchnschr* **4** 913, 1925

Verse, M., in Discussion on Teutschlaender, O., and Stahr, H. *Verhandl d deutsch path Gesellsch* **19** 191, 1923

Bejach, H. E. Beiträge zur Statistik des Carcinoms, *Ztschr f Krebsforsch*, **16** 159, 1919

8 These studies are found in the following articles

Askanazy, M. Ueber die Veränderungen der grossen Luftwege besonders ihre Epithelmetaplasie bei der Influenza, *Cor Bl f schweiz Aerzte* **49** 465, 1919

Schmidtmann, Martha. Einige bemerkenswerte Beobachtungen zur Pathologie der Grippe, *Virchows Arch f path Anat* **228** 44, 1920

Mittasch, G. Ueber die pathologisch-anatomischen Grundlagen der Influenza mit besonderer Berücksichtigung der Gehirnveränderungen, *Frankfurt Ztschr f Path* **26** 406, 1922

Winternitz, M. C., Wason, I. M., and McNamara, F. P. *The Pathology of Influenza*, New Haven, Yale University Press, 1920, p 48

Gaus, A., and Fritzsche, R. Ueber den Sektionsbefund bei der gegenwärtigen Grippe-Epidemie unter besonderer Berücksichtigung der mikroskopischen Befundes *Cor Bl f schweiz Aerzte* **49** 72, 1919

9 Meyer, B. Ein Fall von Epithelmetaplasia und metaplasierendem Carcinom des rechten Hauptbronchus nach Grippe, *Frankfurt Ztschr f Path* **27**. 517, 1922

10 Passler, H. Ueber das primäre Carcinom der Lunge, *Virchows Arch f path Anat* **145** 191, 1896

11 Adler, I. *Primary Malignant Growths of the Lungs and Bronchi*, New York, Longmans, Green & Company, 1921

and Kramer,<sup>12</sup> among 21, and Seyfarth,<sup>13</sup> in a report of 307 carcinomas of the lung, said that metastases in bones occur often chiefly in the ribs, sternum and vertebrae, but rarely in other parts of the skeletal system. It is known, however, that in routine postmortem examinations these bones usually are examined, and many others are not. Commenting on the studies of carcinoma in general by C. Frankel and Fischer-Defoy in which from 26 to 28 per cent of bodies had metastases in the skeleton, Schmorl<sup>14</sup> stated that these figures are too low because only those recognized grossly are reported, whereas a microscopic examination of the bones increases the figures by 6 per cent. He also found secondary growths in bones in bodies with no tumors of viscera usually invaded secondarily.

Dosquet<sup>15</sup> failed to state the number of secondary tumors of the bone in the 105 primary carcinomas of the lung that he found recorded in 2,519 postmortem examinations. All were made by Lubarsch or his assistants, 2,158 at Berlin and 361 at Kiel. Dosquet's review is limited strictly to the frequency of secondary carcinomas in the central nervous system and in the suprarenal glands. He found that secondary tumors developed in these two regions from carcinomas of the lung and from bronchial carcinoma with much greater frequency (from 21.8 to 31.4 per cent) than from other carcinomas (from 0.6 to 3.9 per cent). He also stated that Orth, Veigert, and Goldmann found regularly in invasion of the veins, a so-called "endophlebitis carcinomatosa" with both primary and secondary carcinoma of the lungs which may account for the widespread metastases in the viscera. Schmorl thought that bone marrow favors the growth of metastatic carcinoma tissue.

When histologic examinations are made of the metastatic tumors from primary carcinomas of the lungs, the reports regularly state that the cellular structure is like the primary growth. This, of course, is to be expected, and the structure may be that of "adenocarcinoma (cylindric cells), in which there are glandlike structures lined by one or several layers of cylindric epithelium or large papillary stalks suggesting a papillary adenocarcinoma; the cells sometimes contain vacuoles with mucin or arranged in alveoli filled with a material substance (2) carcinoma simplex in which irregular solid nests of

12 Grove, I. S. and Kramer, S. E. Primary Carcinomas of the Lung. *M. Sc.* 171: 250, 1926.

13 Seyfarth, C. Lungentumoren in Leipzig. *Deut. Arch. Path. Anat.* 50: 1497, 1924.

14 Schmorl, L. Über Krebsmetastasen im Knochen. *Monatsh. Anat. path. Gesch.* 12: 80, 1908.

15 Dosquet, L. Über die Metastasenbildung. *Arch. Path. Anat.* 234: 251, 1922.

16 Barron, M. Carcinoma of the Lung. *Arch. Path. Anat.* 234: 251, 1922.

cords of undifferentiated epithelial cells are surrounded by a connective tissue stroma, (3) alveolar carcinoma, in which there are large solid masses of pleomorphic cells occupying spaces resembling lung alveoli (4) medullary carcinoma in which the cells are small, compact and pleomorphic and have little cytoplasm, this form is sometimes distinguished from sarcoma with difficulty, (5) colloid carcinoma

Primary tumors of the lung giving rise to the metastases vary much in size and appearance. The large bulky tumors are easily recognized, the small ones, sometimes with difficulty. It is generally conceded (Passler, Kikuth, and others) that practically all are bronchiogenic tumors. According to Passler, many are anatomically nearly pure bronchial tumors. Either the bulk of the carcinoma is in the bronchial lumen, constricting and even occluding it, or the tumor develops in the loose peribronchial tissues and penetrates deeply into the substance of the lung. This peribronchial tissue, especially, is involved by the carcinoma, the parenchymatous tissues for large regions are unchanged or show only secondary changes, such as inflammation and compression. Kikuth,<sup>17</sup> in writing about the material at the Eppendorf Hospital, said that these tumors vary greatly in size. They usually lie within a few centimeters of the bifurcation of the trachea, near the origin of the bronchi leading to the individual lobes. There may be an irregular rough thickening of the bronchial mucosa or extremely small and scarcely elevated regions occupying only 3 sq mm of surface. Sometimes the lymph channels are extensively invaded by carcinoma, so that the whole lung, one lobe especially, is studded with innumerable submiliary masses that fill the lymph and blood vessels along the bronchi, extend to the pleura and there form pearly aggregates.

It is scarcely necessary to say that many of these metastases to the pleura have been reported as "endotheliomas," because the postmortem examination and histologic studies failed to reveal the primary tumor. Robertson's<sup>18</sup> extensive analysis of "endothelioma" of the pleura closes with the following statement:

This review apparently proves that only the sarcomas can be classified as primary malignant tumors of the pleural tissues, and that all other growths are secondary, representing extensions, implantations, or metastases from an unrecognized or latent primary source (carcinoma), usually the lungs.

These conclusions by Robertson as regards the "endotheliomas" of the pleura raise a similar doubt as regards the "endotheliomas" of bones.

17 Kikuth, W. Ueber Lungencarcinom, *Virchows Arch f path Anat* **255** 107, 1925.

18 Robertson, H. E. "Endothelioma" of the Pleura, *J Cancer Research* **8** 316, 1924.

An analysis of the reports<sup>1</sup> designated as endothelioma or homoblastoma prior to 1919 demonstrates that only those by Engelmann, Jaffe, Sudhoff, von Lukowicz, Zahn, Spigelberg, Volkmann, and Howard and Crile contain details of postmortem examinations. Engelmann described a huge tumor of the right side of the chest appar-

19 These reports are given in the following articles

Lucke, A. Beiträge zur Geschwulstlehre Virchows Arch 1 path Anat 35 524, 1866  
 Kocher, T. Zur Kenntnis der pulsierenden Knochengeschwulste nebst Bemerkungen ueber hyaline Degeneration (resp. Cylindroma), Virchows Arch 1 path Anat 44 311, 1868  
 Billroth. Ueber alveolare Sarcome, Arch 1 klin Chir 11 244, 1869

Engelmann, G. J. Ueber einen alveolären Tumor mit collöder Degeneration, Inaug. Diss., Berlin, 1871  
 Jaffe. Zur Kenntnis der gefäßreichen Sarcome, Arch 1 klin Chir (Langenbeck) 17 91, 1874

Sudhoff, K. Ueber das primäre multiple Carcinoma des Knochen-systems Inaug. Diss. Erlangen 1875  
 Schweiniger, L. Kurze Mitteilungen aus den pathologischen Anatomischen Demonstrationen des Prof. Dr. v. Buhl in München. Viertel. Intelligenzblatt 23 339, 1876

Von Lukowicz, J. Ein Fall von Gallertgeschwulst des Os femoris. Inaug. Diss., Halle, 1879  
 Kollaczek. Acht neue Fälle von Angio Sarcoma. Deutsche Ztschr 1 Chir 13 1, 1880

Zahn, T. W. Ueber Geschwulststränge durch Capillarenbildung, Virchows Arch 1 path Anat 117 1 1889. Beiträge zur Geschwulstlehre, Deutsche Ztschr 1 Chir 22 14 1885

Hildebrand. Ueber das tubuläre Angiosarcom oder Endotheliom d. Knochen Deutsche Ztschr 1 Chir 31 263 1891  
 Driessens L. F. Untersuchungen ueber epithelreiche Endothelien. Ziegler's Beitr 12 65 1893

Spigelberg, H. Beiträge zur Kenntnis der multipel auftretend. Knochen-sarcome Inaug. Diss. Frankfurt 1894  
 Volkmann, R. Ueber endotheliale Geschwulste und Leukämie. Inaug. Diss. Jena 1895

Markwald. Ueber sogenannte multiple Myelome. Verhandl. d. Anat. Gesellsch. 41 1, 1895  
 Markwald. Ueber sogenannte multiple Myelome. Verhandl. d. Anat. Gesellsch. 41 1, 1895

Landthum in den gesammelten Knochen des Menschen. Virchows Arch 1 path Anat 5 850 1894. Ein Fall von multipel auftretend. Endotheliom in den gesammelten Knochen des Menschen. Virchows Arch 1 path Anat 141 127 1895

Graward, L. De l'Endotheliome des Os. Thèse. Paris 1895  
 Ritter C. Der Fettgehalt in den Endothelzellen. Virchows Arch 1 path Anat 141 127 1895

Berger P. Sur les endotheliomes des os. Revue de Chir 50 247 1895  
 Sternberg, C. Ein Fall von multipel auftretend. Endotheliom. Virchows Arch 1 path Anat 141 127 1895

Schemm Tumor des Knochenmarks. Virchows Arch 1 path Anat 141 127 1895  
 Annat 12 625 1901

ently arising from the ribs, which histologically resembled a colloid struma. The compressed right lung contained small metastatic tumors, but the bronchial and other lymph glands were unchanged. These statements include all the details of the postmortem examination. Jaffé mentioned a tumor of the left ilium and small gray nodules in the lungs and pleura. These contained cells arranged in acini and cylindrical rows. The account of the postmortem examination is brief and a careful examination of the lungs for a primary tumor is not mentioned. The details of the postmortem examination by Sudhoff are meager. He described, in tumors of many bones, tissue like a "glandular carcinoma." Von Lukovicz reported a colloid tumor of the right femur and pelvis found postmortem in the body of a man, aged 60. In the left pleural cavity were more than 25 liters of a bloodstained fluid. The lung was compressed, and the pleura was thickened by (small ?) smooth, flat, tumor masses. The tumor of the femur was composed of tubular structures, some of the lining cells were cylindric. No mention is made of an examination of either lung for a primary tumor. This account is preceded by reference to two reports of metastases of the bone with primary carcinoma of the thyroid. In a discussion of his own observations, von Lukovicz considered the possibility that the tumors are metastases, he was uncertain that the tumor of the bone was primary. The tumors of the bone and pleura, he said, are alike, histologically. He did not make a microscopic examination of the thyroid gland. The tumor at the base of the skull described by Zahn contained alveolar and tubular structures. He regarded the tumor as primary in the skull, but failed to consider the epithelial structures present in these regions.

The dissertation by Spiegelberg contained only a few details of the postmortem examination of a woman, aged 62, who had tumors of the

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Howard, W. T., and Crile, G. W. A Contribution to the Knowledge of Endothelioma and Perithelioma of Bone, *Ann Surg* **42** 358, 1905

Symmers, D., and Vance, M. Multiple Primary Intravascular Hemangio-endotheliomata of the Osseous System Associated with the Symptoms of Multiple Myelomata, a Lesion Hitherto Undescribed, *Am J M Sc* **152** 28, 1916

Ewing, J. Diffuse Endothelioma of Bone, *Proc New York, Path Soc* **21** 17, 1921, *Neoplastic Diseases*, Philadelphia, W. B. Saunders Company, 1919, pp. 312-314, A Review and Classification of Bone Sarcomas, *Arch Surg* **4** 485 (May) 1922

Kolodny, A. A Case of Primary Multiple Endothelioma of Bone with Special Emphasis on Its Roentgenologic Features, *Arch Surg* **9** 636 (Nov.) 1924, *Bone Sarcoma*, *Surg Gynec Obst* **44** 126, 1927

Coley, W. B., and Coley, B. L. Primary Malignant Tumors of the Long Bones, *Arch Surg* **13** 779 (Dec.) 1926, *ibid* **14** 63 (Jan.) 1927

ribs, sternum, right ilium and spleen. The right pleural cavity contained a quantity of turbid fluid, and the lung was markedly compressed. The tumors of the bone contained nests of cells about the size of medium large pavement epithelium, some arranged in tubules and in cylindrical structures. These, Spiegelberg said at first suggested a metastatic tumor, and he mentioned search in the mammae (sopharynx-pancreas and intestinal tract for a primary growth but he said nothing about an examination of the lungs, bronchi, thyroid or certain other viscera for primary carcinoma. He also included a report of a frontal and a sacral tumor received from Ziegler. Histologically these had alveolar structures and resembled those first mentioned. There is no mention of a postmortem examination. Volkmann in his introduction paragraph on "Endotheliale Knochengeschwulste," stated that all of these tumors contain tubules and alveolar structures of epithelial-like cells, often cylindrical, which undergo mucoid or hyaline degeneration or secrete mucin and hyaline substances. Writing at that time (1895) he said that if the morphologic characters of the cells are considered without regard to their genesis, these tumors can be accepted as evidence of a "primary bone carcinoma." He described a huge tumor of the skull in a man, aged 70, who died ten days after the miss had been excised. Postmortem examination did not reveal any metastases in the body. In the details of this autopsy record edema and emphysema of the lung are mentioned. Microscopically, the spindle cell stroma of the tumor contained ductlike structures with cylindric epithelium that resembled closely, as he said a carcinoma of the bowel. Volkmann also included a description of tissues given him by Dr. Marchand these being the ones von Lukowicz described in his dissertation. Volkmann thought that the pleural tumors unquestionably are endothelial but von Lukowicz said that the cells in these growths cannot be distinguished from epithelium.

The report by Markwald, in 1895 is mentioned frequently in connection with the study of the histology of the lungs. It records the results of a postmortem examination of the body of a man aged 56 which demonstrated destructive tumors of the bones (calvarium vertebrae ribs bones of the pelvis and scapulae, etc.), but none in the viscera. The tumors were arranged in solid masses and cords which he says, suggested carcinoma. A vascular fibrous stroma supported the cells. In brief statements of the postmortem examination the following points are to be small and heavy and the posterior portions of the lungs had sharply circumscribed solid pieces that contained a hydropneumonia in the lower and middle lobes. The report of a histologic examination of the lungs is as follows:

a careful examination of the bronchi for carcinoma Markwald seems to have been uncertain in his interpretation of these tumors because the title of his brief account is "Ueber die sogenannte multiple myeloma", that of his more extended report includes the terms "myelom, angio-sarcom" It is clear, at least, that in assuming a multiplicity of primary tumors of bones he is incorporating ideas generally held regarding multiple myelomas, and so he does not differentiate between a primary tumor and tumor metastases

The tumors of the bones in the body of a woman, aged 66, described by Sternberg were limited to the medulla and did not destroy the cortex The cells in these tumors were "signet ring" like those of a Kruckenberg tumor of the ovary, and are unlike those in other descriptions of these tumors of the bone One of the two autopsy reports by Howard and Crile mentioned changes like those contained in the reports by Jaffé and von Lukovicz, the other described such widespread tumor growths that even the authors were in doubt as regards the primary tumor This, they thought, was somewhere in bones, although grossly the tumor tissues resembled carcinoma

Other reports (Lucke, Billroth, Schweiniger, Spiegelberg [case 2], Kolaczek, Hildebrand, Driessen, Gaynard, Ritter, Berger, Howard and Crile [case 2], Summers and Vance) sometimes mentioned with this group of tumors, are without the results of postmortem examinations and are based on the study of surgical material These reports, in general, make little comment about the further progress of the disease, and the conclusions permitted by a study of such material are limited

After these earlier reports there was little mention of "endotheliomas" of the bone until the accounts by Ewing These described three varieties (1) the multiple endotheliomas, which involve many bones, occur usually in adults, generally are fatal with metastases to the lungs, and are composed of endothelial-like cells in small groups or "sheets," often alveoli, and sometimes contain cysts with serous or mucinous fluid, (2) angio-endothelioma, and (3) solitary diffuse endotheliomas which occur in young patients

The single bulky circumscribed tumors arise in the bone marrow, soon perforate the cortex and develop externally The structure is a tubular or alveolar endothelium, mucoid and hyaline degeneration occurs, and cysts may be present Typical of these tumors are the two described by Volkmann But, as has been mentioned, Volkmann stated that the one of the skull closely resembles a carcinoma of the bowel, while the other of the right femur, described originally by von Lukovicz, occurred in the body of a man with multiple small tumors of the left pleura, like metastases of a primary lung or other carcinoma The multiple endotheliomas of the bone affect nearly every bone in the body, as described in the report by Markwald

There is no mention of the results of careful postmortem examinations in any of these accounts by Lwing and in the discussion in his report at the meeting of the New York Pathological Society. Dr Symmers asked whether there was any possibility that these patients suffered from a primary tumor of the kidney notably the so-called hypernephroma which often metastasizes to bones and the structure of which is not unlike that of the preparation illustrated

Kolodny reported "a primary multiple endothelioma of bone, based on the study of surgically removed tissues and of tissues obtained by a postmortem examination. The first statements of the microscopic examination are as follows: "The arrangement of the tumor cells in alveoli and tubules was similar to that of an adenomatous growth. This together with the large-sized cylindrical and polygonal flat cells abundantly present in the sections, easily gave an impression of a carcinoma. His subsequent statements argue in favor of origin from blood vessel endothelium. The mediastinal and mesenteric lymph nodes were involved extensively, and the lungs contained multiple miliary nodules. It is regretted that the report contains so little of the details of the postmortem examination (by Dr Orton). The only statement being on the thoroughness is contained in the sentence: "The necropsy was performed as completely and carefully as possible. Dr Orton giving especial attention to the possible occurrence of a primary tumor of the soft tissue." There is no discussion of the significance of miliary tumors in the lungs and lymph nodes.

A summary of fifty-four endotheliomas of bones in the collection of the American College of Surgeons is contained in a report by Connor. Approximately one half of the fifty-four patients mentioned by Connor died according to his statements postmortem examination was made in less than one third. Careful study of his individual reports available to us of course may not contain all of the information available to us to demonstrate just how completely or thoroughly any of these postmortem examinations were made. There also is considerable doubt as to the final status of the patients listed as living. Kolodny and Connor in a somewhat later report said that one of the patients reported in Connor's list as having died possibly still is reported in Connor's list as having is dead possibly still is metastasis but add that no postmortem examination was made. The patient lived at least five years after the operation. There are only six others in the entire list of living patients that have lived as long or longer. Kolodny and Connor observed twenty-six patients with tumors were reported in the summary of the bones. Accounts of postmortem examination of those dead are not contained in the report. Of these diagnoses were made in 1925-32.



histologic examination of the tumor Kolodny's report of the material contained in the registry of bone sarcomas of the American College of Surgeons has a section dealing with these tumors designated as "Ewing's sarcoma" His account is a restatement of features already mentioned and includes no new information gained by postmortem examinations

Of the reports after 1919, the ones by Ewing do not contain any statements of the results of postmortem examinations, and the one by Connor mentions such results only in a general way Of the 18 patients that died (cases 30, 31, 33, 36, 37, 38, 39, 40, 41, 45, 46, 47, 48, 50, 51, 52, 53, 54) and in which some mention is made of tumors other than the ones first recognized clinically in bones, there are thirteen which specifically record the presence of tumors of the lungs Of the eighteen patients reported by Coley and Coley (Cases 4, 8, 9, 11, 20, 21, 22, 23, 25, 32, 34, 36, 37, 42, 43, 48, 49 and 54), five died, and the body of only one was examined post mortem Accounts of this examination (case 49) are limited to the brief comment that there were "very extensive metastases into nearly every organ and bone of the body"

These solitary and multiple destructive tumors of bones containing masses of cells resembling epithelial structures, such as alveoli and tubules, have been designated primary endotheliomas because the cells are said to be arranged along the walls of capillaries and because of certain details of internal structure The use of this term implying origin from vascular tissue seems to have begun at a time when Virchow's teaching that carcinoma may arise from connective tissue was discarded, and in explanation of the presence in bones of tumors resembling carcinoma some vascular tissue derivation was offered In not a few instances this deduction has followed directly, and the author has been in considerable ignorance of the conditions in other parts of the body of his patient at the time his report was written, because he had only surgical material for study In other instances, when tissues obtained by postmortem examination were studied, conclusions of vascular origin were drawn because a primary tumor was not found in the viscera Among these are reports in which doubt exists as regards the thoroughness and completeness of the examination That solitary vascular tumors occur is not denied, and that secondary growths (metastases) originate from a primary malignant tumor also follows in logical order In none of the reports mentioned, however, except the one by Connor, is the mechanism of metastasis from a primary tumor considered in explaining the presence of the so-called multiple primary endothelioma in many bones Instead, each tumor is regarded as arising independently

A number of years ago, Bassoe<sup>20</sup> reported a primary tumor of the pleura with the outstanding feature that the growth produced an unbroken chain of proliferating lymph channels which extended from the cervical and axillary glands above, along the right pleura through the lymphatics of the diaphragm, and spread over the entire parietal and visceral peritoneum to the thoracic and pelvic lymph nodes below. Isolated metastases were not found in any organ. Hirschman<sup>21</sup> in a critical review years ago, took the stand that many reports of endothelioma really concerned carcinoma. He emphasized the tendency to describe as endothelioma any tumor with cells arranged in cords and agreed with Benda that no dependence should be placed on the relation of tumor cells to the lining cells of the lymph channels as a criterion of endothelioma.

The assumption of multiple primary foci in bones as an explanation of coincident tumors in various parts of the skeleton seems due to the failure to find a small primary carcinoma in the relatively small number of postmortem examinations of the bodies of these patients or to the inability to distinguish the primary growth from the secondary in the presence of many tumors in different tissues. Therefore, it is generally held in explanation of the existence of multiple myelomas in bones that been included with the "multiple endotheliomas of bones." As the result of such interpretations of a limited postmortem material there are many reports based only on the examination of tissues removed surgically without regard for conditions in other parts of the body. Some of these have been made at a time when the ultimate clinical result in the patient could not be determined was unknown, or perhaps not sought.

This dearth of information about conditions elsewhere than in the bones in the bodies of these patients is probably the greatest obstacle to the way of gaining a generally accepted opinion of the position of the so-called "endotheliomas" among the tumors of bones. Such information will be obtained by careful and thorough postmortem examinations of the bodies of these patients supplemented by a thorough necropsy of the changes thereby demonstrated. Most of the observations against a confusion with metastatic carcinomas. It would be desirable, therefore, that conclusions drawn from studies based on the examination of removed tissues without a careful postmortem examination be discarded, although physical and roentgen-ray examination of the value

<sup>20</sup> Bassoe Peter. Report of a case of endothelioma of the pleura.

Tr Chicago Path Soc 6: 31, 1917.

<sup>21</sup> Hirschman. Endothelioma of the pleura.

## SUMMARY

Metastases to bones, as stated by others, occur in a large number of patients with primary carcinoma of the lungs

In a certain number of patients with such secondary carcinomas, the symptoms caused by the tumors in the bones dominate the clinical course of the disease

The clinical course and the results of postmortem examinations are reported in four patients in whom the bone metastases from a primary carcinoma of the lungs caused the chief symptoms

The secondary tumors removed surgically from two of the patients during life were diagnosed by some pathologists as so-called "primary endothelioma" of the bone

One of these primary carcinomas of the lungs with metastasis to the left tibia occurred in a boy 6 years of age at the time of death. A year before he died, tissues of the tumor of the bone were diagnosed metastatic carcinoma, and at that time a careful physical examination failed to disclose the primary tumor

An analysis of the reports of so-called endotheliomas of bones demonstrates that many of these are based on a study of tissues removed surgically from patients whose bodies were not examined after death, or were examined without the care necessary to disclose a primary carcinoma, especially of the lungs

Metastatic carcinomas are easily confused with other tumors of the bones, and therefore a diagnosis of "endothelioma of bones" in surgically removed tissues containing epithelial-like cells in alveoli and tubules, has doubtful basis. A thorough and careful postmortem examination later, by which all parts of the body are examined, provides the necessary information for a correct conclusion. The results of the postmortem examinations reported here demonstrate that tumors said by some to be endotheliomas of bones occurred in bodies in which we believe there is a primary carcinoma of the lungs

In the search for a primary tumor in patients with carcinoma metastases in bones, the lungs should be included among the probable sources

# SINUS PERICRANII (REDUCIBLE BLOOD TUMOR OF THE CRANIUM)

ITS ORIGIN AND ITS RELATION TO HEMANGIOMA AND ABNORMAL  
ARTERIOVENOUS COMMUNICATION REPORT OF A CASE

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Sinus pericranii is the name most frequently used in the European literature to designate a blood cyst or hemangioma of the pericranium communicating with an intracranial blood sinus by one or more abnormal foramina in the skull

Clinically, sinus pericranii presents a soft, compressible, fluctuant swelling which increases in size when the patient assumes a posture with the head down, when he flexes his neck sharply, or when he raises his intrathoracic pressure by coughing, crying or making an expiratory effort with the glottis closed. Digital compression of the jugular veins also causes the swelling to grow larger. Indeed, the lesion may not be apparent unless some of the factors that increase intracranial venous pressure are active. A bluish color is sometimes visible through the skin over the swelling, but when it is not, the tumor is easily mistaken by the unwary for a meningocoele. The roentgenogram of the skull generally shows an area of rarefaction or a perforation corresponding to the situation of the tumor.

Few, if any, symptoms accompany the anomaly. Pain of moderate severity and vague cerebral disturbances have been recorded in some of the reported cases. The age incidence is from birth to late maturity. Many of the cases in older subjects are significantly related to antecedent trauma. In most of the cases, the lesion has been progressive, frequently starting as a small nodule and gradually developing into a tumor several centimeters in diameter.

When first described and named by Stromeyer, and for many years thereafter, the lesion was considered a noli me tangere. When treatment was administered, the methods were generally such as to destroy the specimen as far as any pathologic investigation was concerned. In more recent years, aggressive surgical methods of treatment have yielded specimens for examination. Nevertheless, it is remarkable that few searching pathologic examinations are recorded. From most of the descriptions, which are sufficiently detailed to warrant judgment, it

\*From the Laboratory of Surgical Pathology of the Indiana University School of Medicine. The permission of Dr. W. D. Gatch to publish the case reported in this article is hereby acknowledged.

appears that the lesion is generally of the nature of a cavernous hemangioma. It is usually circumscribed and limited to the pericranium. One or more anomalous emissary veins, piercing foramina in the skull, place the blood spaces of the tumor in relation with one of the large intracranial blood sinuses. In the recorded cases available there has been a singular paucity of careful notes regarding tributary vascular channels in the pericranium.

The lesion must be relatively unusual. Mastin,<sup>1</sup> in 1886, found fifty-five references in the literature. Only three of these articles were in the English language. Cohn,<sup>2</sup> in 1926, found fourteen additional references, one of which was in English, but overlooked the excellent paper by Mastin, who reported the first American case so far as can be determined. Cohn cited Cushing's<sup>3</sup> brief reference to the condition in Keen's "Surgery." I have collected sixteen additional references, three of which are in the English language. I was able to find eighty-four references to articles on this condition, seven of which are in English, including Cushing's brief description.

It is improbable that the disparity between the literature in English and in foreign languages is due to the fact that a greater number of cases have occurred in continental Europe. It is altogether more likely that the cases reported in England and America are lost in the literature under such titles as "angioma," "aneurysm by anastomosis," and "cirroid aneurysm." Mastin listed fifteen terms under which he found the condition described. These are thought worthy of quotation, together with four others which I have added: *Varix verus cirsoideus*, *varix verus circumscriptus*, *fistule osteo-vasculaire*, *erectile tumors of the skull communicating with the superior longitudinal sinus*, *sinus pericranii*, *varix sinus verus extra-cranium congenitalis*, "venous tumors" of the cranial bones, *varix spurius circumscriptus venae diploicae frontalis*, *sanguineous hernias of the vault of the skull by communication with the intracranial venous circulation*, *sanguineous hernias of the vault of the skull by communication through openings in the bone of the meningeal vessels with the exterior integument*, *varicose veins or venous varicosities of the skull*, *a new form of tumor of the vault of the cranium, produced by the blood in communication with the intracranial venous circulation*, *subpericranial venous tumors*, *reducible sanguineous tumors of the vault of the cranium*, *aneurysmal tumors of the temporal region*, *cephalematocoele*, *hemangioma*, and *cavernoma*.

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1 Mastin, W. M. Venous Blood Tumors of the Cranium, *J. A. M. A.* **7** 309 (Sept. 18) 1886.

2 Cohn, Isidore. Sinus Pericranii (Stromeyer), *Surg. Gynec. & Obst.* **42** 614, 1926.

3 Cushing, Harvey. Sinus Pericranii, in Keen, *Surgery*, Philadelphia, W. B. Saunders Company, 1919, vol. 3, p. 33.

I believe that the name sinus pericranii should be applied consistently to the lesion in question in consideration of the peculiarities that it owes to its special relation with intracranial circulation, regardless of the pathologic category to which it may eventually be assigned. This name has the additional merit of priority and historical association.

#### REPORT OF A CASE

The patient with the case of sinus pericranii to be described in the following paragraphs was referred by Dr B R Kirklin, now of the Mayo Clinic, to Dr W D Gatch who performed the operation, at which I assisted.

A T, aged 16, was admitted to the Robert W Long Hospital, March 28, 1923, complaining of pain in the forehead associated with a tumor under the skin in that region. The family history did not present any significant facts. The patient fell on a stone at the age of 5 years, cutting his forehead at the site now occupied by the tumor. The wound healed uneventfully. At the age of 8, a small, hard lump appeared on the right side of the forehead just below the hair line. The lump was painful, and the skin over it was tense. The lump later became soft and gradually increased in size. The patient occasionally had headache associated with throbbing pain in the affected area, otherwise there were no neurologic symptoms.

The patient was of good physique and well nourished. There were no abnormalities other than the tumor. It was not present when the patient stood or sat erect. On close inspection, an area of skin 4 cm in diameter at the right of the midline just below the hair line appeared a little coarse in texture. Palpation of this area revealed an oval depression about 3 mm deep in the cranium. The bony border was irregular but not appreciably raised. The floor of the depression was flat, and no orifice could be felt in it. When the patient inclined the head forward, a rounded tumor gradually appeared. The color of the skin did not change. Palpation now revealed a soft, fluctuant mass which did not move over the cranium, but over which the skin was freely movable. There was no pulsation, thrill or bruit. The mass was opaque to transillumination. The roentgenogram made by Dr Kirklin showed an area of apparent complicate absence of bone in the region occupied by the tumor. At the margin of this defect, the tables showed an angular separation. A visiting surgeon, by no means expert or inexperienced, considered the lesion a meningocoele. Nevertheless, the preoperative diagnosis was "hemangioma communicating with the intracranial circulation."

Under ether anesthesia, a U-shaped incision was made. The limbs extended upward, outlining a flap exceeding the tumor in size by about 1 cm. The flap of scalp was turned forward, disclosing a turgid, rounded mass in the pericranium. The pericranium was incised to the bone close to the margin of the tumor. Several arteries in the pericranium crossing the margin of the tumor required clamps. The tumor was cautiously elevated until several narrow vessels were seen passing from its inferior surface into orifices in the cranium. Ligation of these delicate vessels was impracticable, and the entire mass was quickly stripped off the bone. This procedure left about ten small actively bleeding veins. All bleeding was stopped by electrocoagulation. The bone under the tumor presented an oval depression exactly corresponding to the size of the tumor. The floor of

the depression was flat and apparently on a level with the inner table, as the depth of the depression was about the estimated thickness of the outer table and diploe. The margin of the depression was smooth. The outer table of the surrounding normal bone merely shelved down abruptly to become continuous with the floor, which was sievelike by virtue of about ten foramina each of which was occupied by the stump of a delicate vein. The flap of scalp was sutured in place without drainage. Recovery was uneventful. The scar was inconspicuous. In January, 1924, the patient reported that there had not been a recurrence of the tumor or of the symptoms which were associated with it.

*Pathological Study of the Tumor*—The gross specimen was a disk of spongy tissue about 5 cm in diameter and 0.5 cm thick. One surface, the upper or outer, was velvety and pink, resembling areolar tissue. The obverse surface, which was applied to the bone, consisted of a thin, tough, white membrane. When this



Fig 1—Front view of patient with head erect

membrane was stretched, ten orifices about 1 mm in diameter became apparent. These orifices led into cavernous spaces immediately under the white membrane. The spaces were traversed by delicate septums which merged into the spongy tissue, making up most of the thickness of the disk. In cross-section, this spongy zone was seen to contain numerous small vessels of moderately thick walls.

Microscopic sections showed three merging zones. The one corresponding to the tough, white membrane was a layer of dense avascular connective tissue. Delicate partitions of connective tissue extended from it into the middle zone, which consisted largely of irregular sinuses lined by endothelium. Serial sections established the fact that these sinuses communicated with each other. Some of the partitions between the sinuses were provided with abundant small vessels. The zone corresponding to the pink velvety surface of the specimen was composed of this vascular connective tissue, which in this situation was more dense than in the middle zone and not interrupted by sinuses. A section through one of the orifices in the tough, white membrane showed merely a gap in the avascular zone.

Although the contour was smooth, the margins of this gap did not show any endothelium. The sinuses into which the gap opened, however, were provided with endothelium. It was probable that the endothelial lining in the region of the gap was stripped off and remained with the stumps of the emissary veins when the disk was peeled off the cranium.

Serial sections showed numerous instances of communication between small vessels of the connective tissue septums and the sinuses. Every communication was of capillary dimensions.

One series of sections showed a mass of granulation tissue protruding from the wall of a sinus. A sheet of fibrin and numerous granules of hemosiderin were associated with this mass, which apparently marked the site of a vascular accident a parietal thrombus or a hemorrhage into the areolar tissue adjacent to the sinus. Numerous communications could be demonstrated in the serial



Fig 2—Front view of patient with head bent forward

sections between the capillaries of the granulation tissue and the sinus into which it protruded

Sections stained to show elastic tissue revealed numerous elastic fibers in and about the walls of the sinuses. In many places, these elastic fibers were laid down circumferentially with respect to the sinuses. Some of the thinner septums did not contain elastic tissue, but most of the thicker ones contained much of it. The incidence of so much elastic tissue and its relation with the blood spaces are evidence in favor of the view that the entire lesion arose from previously existing blood vessels and not by organization and canalization of a hematoma. The pathologic diagnosis was "cavernous hemangioma of the pericranium."

#### PATHOLOGIC CONCEPTION OF SINUS PERICRAVIA

Much of the early literature on sinus pericranii was devoted to controversial discussion of the mode of origin. The earliest explanation was that of Stromeyer who assumed that a traumatic subperiosteal hema-



toma acquired communication with intracranial blood sinuses by way of torn emissary veins. This crude explanation was bolstered by later writers by assuming coincident fracture of the outer table of bone, by hypothecating some obscure interference with the coagulation mechanism and by unusual erosion of the skull bone by pachyomian granulations. Practically all of the authors saw the inadequacy of such mechanical theories when applied to cases of sinus pericranii occurring without a history of trauma and showing progressive growth. In order to render their theories tenable, these observers were required to distribute the cases in a classification which generally took the form of (*a*) traumatic cases, (*b*) spontaneous cases and (*c*) congenital cases. Still more complicated classifications based on structural peculiarities were elaborated.



Fig. 3—Side view of patient with head bent forward

The mechanical theory of formation was rather generally agreed to for the traumatic cases. The congenital cases were attributed to some "morbid conditions of the skull veins" such as "true angioma." The spontaneous cases were attributed to the development of a "varix" followed by pressure erosion of the skull. According to one theory, a rarefying osteitis is the primary lesion which leads to an alteration in the structure of the dural and pericranial vessels.

That the detailed classification of cases is unjustified is apparent from the fact that the structural characteristics of the specimens do not correspond with the groups separated from each other on an assumed etiologic basis. The angiomatous type of lesion is found as often in the traumatic group as in the congenital.

The foregoing criticism is made only with reference to cases following the typical course of sinus pericranii, by that I mean cases with a duration of months or years and in which gradual growth is apparent. It is true that there are recorded a few cases obviously due to gross trauma in which death occurred shortly after the injury and in which the lesion was primarily a fracture complicated by a hematoma communicating with an intracranial blood sinus. Such cases should not be included in the group "sinus pericranii", in fact, it was the inclusion of these cases which led to the over classification and the erroneous theories of origin.

Ernst Mueller<sup>4</sup> vigorously attacked the traumatic theory of origin, examining in detail the reports of twenty cases attributed to trauma by the authors of the reports. The histologic study of the specimen in



Fig. 4—Roentgenogram of patient's skull. The apparent complete absence of bone in the lateral view at the point designated by the arrow is misleading, as a fenestrated plate of bone was demonstrated at operation.

his own case convinced him that he was dealing with a true "cavernoma, a venous angioma." "On looking over the whole series of three groups (congenital, traumatic, and spontaneous) we find, discarding the large group in which no decision is possible, that the picture of varicose dilatation of subcutaneous skull veins or emissaries on the one hand, and hermal protrusions of the dural sinus on the other, is found in all groups. Angioma with the symptoms of sinus pericranii occurs congenitally and as a result of trauma. Such angiomas occur not only congenitally, but as Lannelongue points out, they may develop later."

<sup>4</sup> Mueller, Ernst. Zur Frage des Sinus pericranii, Ztschr. f. ang. Anat. 3 93, 1918.

Achilles Mueller,<sup>5</sup> citing Lannelongue's similar opinions, concluded that most of the cases represented true angiomas "A traumatic origin in the sense of Stromeyer is unlikely and there is no proof of it"

Sudhoff<sup>6</sup> admitted the plausibility of the traumatic explanation for the cases arising after gross trauma, but left the inference that he agreed with Demme<sup>7</sup> that the congenital cases were due to "genuine varix" communicating with intracranial sinuses Mastin ascribed most of the cases he collected to "angioma"

I am convinced that all the cases of typical sinus pericranii, that is, cases with an extended duration and a reasonably long period of gradual development, are characterized by a lesion of the structural type of hemangioma The hemangioma in a case of sinus pericranii is exceptional only because of its special relations These special relations con-

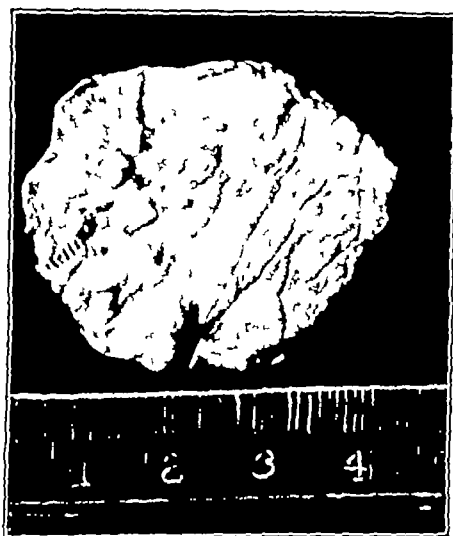


Fig 5—The gross specimen The surface shown is the one which was applied to the skull The minute orifices left by the avulsion of the emissary veins are barely visible Most of them are obscured by the wrinkles in which they lie

sist of a communication with the dural sinuses by way of emissary veins on the one hand, and with vessels of the pericranium on the other hand

I see no reason for separating the "spontaneous" cases from the "traumatic" In the latter, the trauma is frequently trivial, and in the spontaneous cases, similar trauma may easily have been unnoticed or forgotten Even some of the "congenital" cases may have been traumatic,

5 Mueller, Achilles Ueber Sinus pericranii, Berl klin Wchnschr **49** 1372, 1912

6 Sudhoff, Walther Ueber eine neue einfache Operationsmethode des Sinus pericranii, Deutsche Ztschr f Chir **186** 98, 1924

7 Demme, Hermann Ueber extracranielle mit den Sinus durae matris communicirende Blutcysten, Virchows Arch f path Anat **23** 48, 1862

although it is undisputed that a hemangioma or varix can arise as a result of a defect of development in the common anlage of arteries and veins

# CONCEPTION OF SINUS PERICRANII (AND OTHER SIMPLE HEMANGIOMAS) AS AN ANOMALY RESULTING FROM ABNORMAL ARTERIOVENOUS COMMUNICATIONS

The origin of sinus pericranii is explained by identifying the lesion with hemangioma only for those who are satisfied with the traditional concept of hemangioma as a neoplastic entity. Mont Reid<sup>8</sup> advanced excellent reasons for abandoning the occult concept of neoplasia with reference to simple hemangiomas, which he believes are the result of

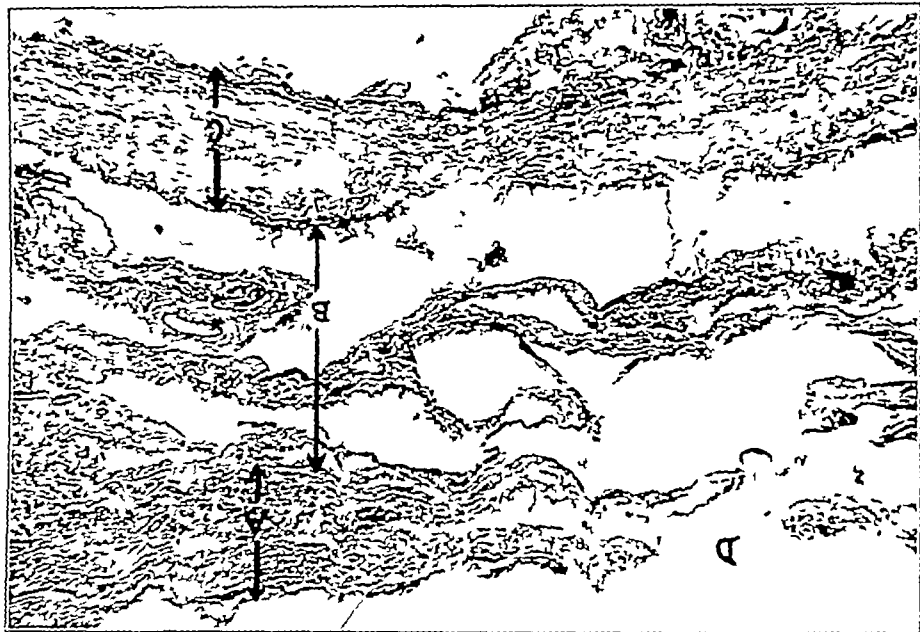


Fig. 6—Low power photomicrograph of a cross-section of the specimen. *A* indicates the avascular membrane which was applied to the skull, *B* the middle zone of cavernous spaces, *C*, the vascularized zone forming the upper surface of the tumor, *D*, the gap representing the orifice left by the avulsion of a vein penetrating the cranial bone.

abnormal arteriovenous communications. Simple hemangioma does not bear a resemblance to true neoplasms which are characterized by a proliferation of cells as units. It is true that there are vascular tumors of progressive growth which are attended by marked proliferation of endothelial cells, but these lesions are excluded from the simple hemangiomas and called hemangio-endotheliomas to designate their blastomatous character. The frequency with which trauma antedates the

development of a hemangioma suggests a mechanical cause. The regional incidence of hemangioma corresponds to a traumatic theory of origin, for it occurs most frequently where soft parts are easily compressed between a blunt object and underlying bone. It is true that hemangiomas appear to grow as do neoplasms. Reid has shown similar progressive growth of a restricted part of the vascular bed as a result of experimentally produced arteriovenous fistules. Most convincing of all the

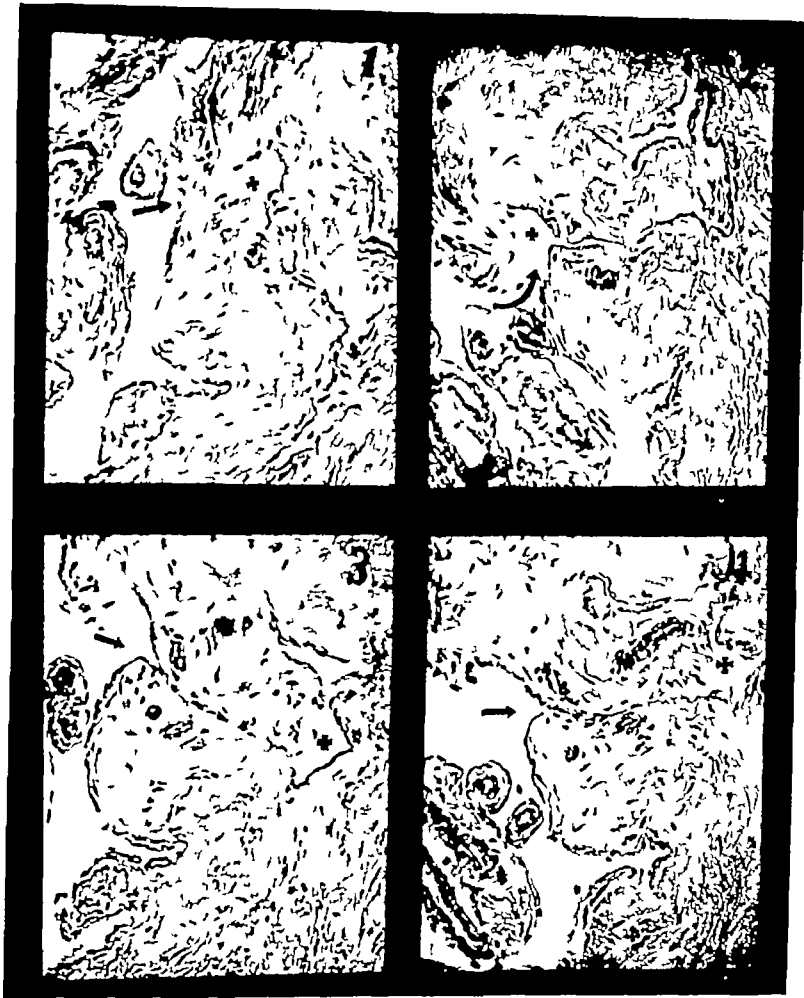


Fig 7—Four sections from a series, showing the communication between a cavernous space and a group of vessels in the adjoining connective tissue partition. The arrows mark the cavernous space. The crosses mark the network of vessels.

evidence is the finding of arteriovenous communications in progressively growing hemangiomas.

So far as I am able to ascertain, no writer has considered the possibility that sinus pericranii is caused by the formation of abnormal arteriovenous communications. If this thesis can be sustained, Reid's belief will have received additional support in view of the typical hemangiomatous structure of the tumor in sinus pericranii.

Certain features in the case reported, as well as similar observations recorded in the literature, favor the view that the hemangioma is caused by arteriovenous fistulas. Blood vessels radiating around the lesion in the pericranium required clamping when the tumor was resected. These were not large or tortuous, nevertheless, they provided communication between the hemangioma and the surrounding peripheral circulation. The specimen, as noted in the pathologic description, showed numerous instances of direct communication between the small vessels of the septums and the cavernous spaces. Further, the capillaries of the granulation tissue arising from the wall of one of the cavernous spaces opened freely into the space. The presence and the arrangement of the elastic



Fig 8—Section through the patch of granulation tissue. The arrow lies in a cavernous space and points toward an opening into the capillary system of the granulation tissue

fibers of the tumor mass indicated its origin from previously existing blood vessels

The absence of thrill and bruit may be cited as evidence against this theory. Some of the reported cases, as the one reported by Demme, however, were characterized by thrill and bruit. In those which do not present these physical signs, one needs merely to assume that the arterial communications are of small caliber.

My view of sinus pericranii, then, is that insignificant trauma may cause abnormal communications between small arteries of the pericranium and emissary veins. Once established, these fistulas cause dilatation and tortuosity of the veins subjected to the abnormal pressure

Gradually other fistulas are formed as the walls of the vein become attenuated and as the arterial elements dilate. In this manner, a congeries of vascular channels is built in which it is impossible to distinguish arteries from veins. The dilatation of the emissary veins extends to the adjacent diploic veins, and the bone of the cranium gradually undergoes absorption as a result of the constant pressure of the vascular lesion. The communication with the intracranial sinus is not an anomalous condition, in fact, the communication existed by way of the diploic veins and minute emissaries before the "aneurysm by anastomosis" became established. The single and essential element in the etiology of the lesion is

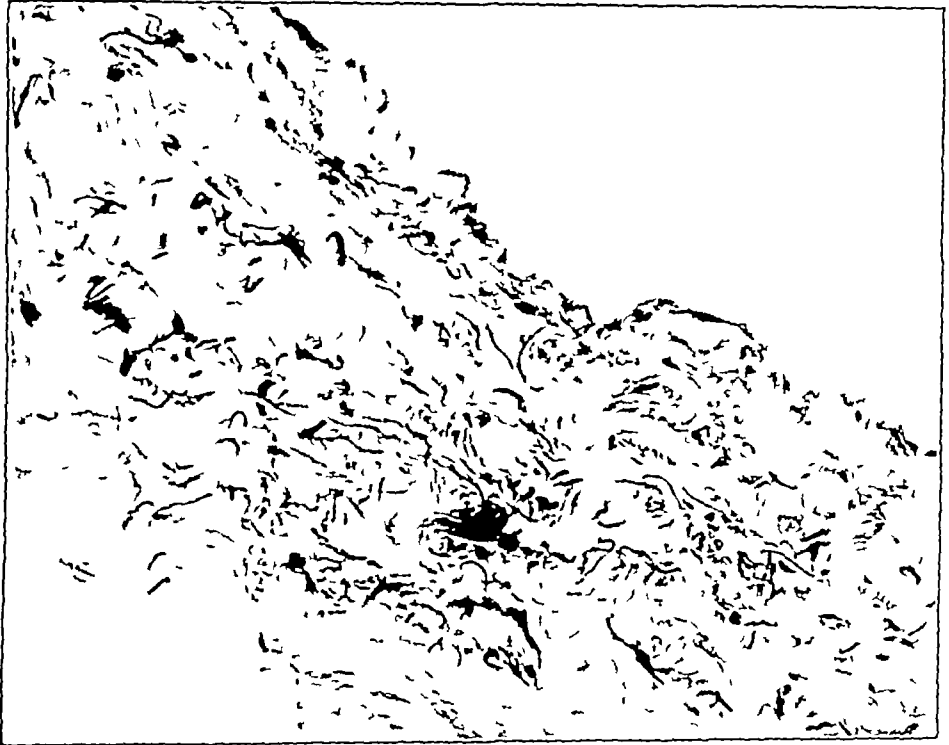


Fig 9—Section of the wall of one of the cavernous spaces, stained for elastic tissue. The black lines represent elastic fibers.

the transmission of arterial blood velocity and pressure into the emissary veins or into veins communicating with them. Such abnormal communications might arise congenitally as a result of faulty development of the arteriovenous anlage, but most of the cases are doubtless traumatic in origin.

#### TECHNICAL POINTS IN THE SURGICAL TREATMENT OF SINUS PERICRANII

The chief consideration in devising operative methods for the treatment of patients with sinus pericranii has been to avoid dangerous or fatal hemorrhage. Some operators have been led to employ extensive craniotomies in order to deal safely with large vessels running through

the cranium and communicating with the longitudinal sinus. When the pedicle vein is large, doubtless through exposure is an element of safety. Wooden pegs, ivory pegs, and plugs of wax have been employed for the occlusion of small foramina, all with some success. Dr. Gatch and myself conceived that electrocoagulation would secure ideal hemostasis as the emissary veins were of small caliber. The result in every way justified our expectation. We considered that rigid occlusion of the foramina is unnecessary, as the lesion is permanently healed by the resection of the central mass of arteriovenous fistulas. The method we employed has the advantage of leaving no foreign substance in the tissues and the desirable feature of speed and certainty. Electrocoagulation may prove to be a valuable adjunct in all craniotomies which are often attended by obstinate bleeding from emissary veins and diploic vessels.

#### SUMMARY

1 "Sinus pericrani" is the term best adapted by reason of historical connections to designate a hemangioma of the pericranium communicating with intracranial blood sinuses and characterized by distinctive symptoms.

2 A patient with sinus pericrani of traumatic origin is reported as cured by resection of the extracranial hemangioma.

3 The use of electrocoagulation to control bleeding of emissary veins is reported.

4 Arteriovenous communications of capillary dimensions were demonstrated in the specimen obtained at operation. Such communications provide a dynamic explanation of the origin of sinus pericranii.

5 Histologic evidence that the hemangioma in this case was due to abnormal arteriovenous communications is interpreted as reinforcing Reid's conclusions that all simple hemangiomas are of such origin.



# CHRONIC APPENDICITIS \*

HARRY KOSTER, M D

BROOKLYN

It is common knowledge that many abdominal explorations made after chronic appendicitis has been diagnosed have revealed an insufficient pathologic process to warrant the section, and that the patients, after removal of the appendix, have been discharged without any relief from primary symptoms and perhaps, subjectively, in a worse condition than before the operation. So much has been said and written about the commission of such errors in diagnosis that the pendulum has swung the other way, and many physicians refuse to acknowledge the presence of a condition that might properly be termed chronic appendicitis.

The statement that there is no such entity as chronic appendicitis, even if based only on clinical experience, would warrant consideration, but the claim that there is no pathologic basis for the use of the term merits the most careful investigation before such a statement be accepted. To obtain the proper conception and the proper evaluation of the data it is necessary to correlate the clinical and the pathologic observations.

The clinical history and signs play the minor rôle in the final analysis. A study of the microscopic changes in the tissues is as near an approach to the physical basis as is at present obtainable. While the interpretation of a section of tissue is subject to the "personal equation" variation of opinion, on the whole, the microscopic picture of chronic inflammation is well established, and the disturbances and processes termed chronic inflammation in general pathology are found to vary but little when studied in special organs. Therefore, in conformation with the method employed in other problems, the pathologic picture, gross and microscopic, must be accepted as final. Then, if the clinical signs do not accord with the diagnosis, either there have been errors in observation and interpretation or diagnostic aids of greater precision should be sought.

From Sept 8, 1922, to Feb 1, 1927, I performed 1,087 abdominal sections for appendicitis, ninety-two of which were performed after a preoperative diagnosis of chronic appendicitis had been made. A personal study of the ninety-two patients from a clinical and pathologic standpoint furnishes the subject matter of this paper. Clinical and pathologic observations concerning many appendixes removed in the course of some other operation are also contributed. It is hoped that this study may result in so changing the nomenclature of certain clinical and pathologic conditions referable to the appendix as to make it

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\* From the surgical service of the Brownsville and East New York Hospital

possible for those who aver and those who deny the existence of "chronic appendicitis" to meet on common ground and to speak a similar and mutually intelligible language. The great diversity of opinion on the existence of such an entity as "chronic appendicitis" and the great variation in the criteria used by the proponents to define the pathologic picture of this disease shows that such a result is desirable. Dr A. A. Eisenberg, the pathologist of the institution in which this study was made, showed me twenty answers to a questionnaire sent to the most prominent clinicians in the United States, in which, among other inquiries, was one regarding the microscopic picture of what was termed chronic appendicitis. No two answers were similar and all were contradictory. These confusing results helped to stimulate this study.

No attempt will be made to discuss the details of diagnosis of chronic appendicular disease. It is definitely believed that the correct diagnosis of this condition should invariably be a result of the exclusion of all other possible diseases. All of these cases were thoroughly investigated before operation and due attention was paid to the possibility that some other lesion might be responsible for the symptoms of which the patient complained. Cystoscopy, ureteral catheterization and pycelography are procedures not to be rashly and indiscriminately prescribed, but in cases of chronic appendicitis such routine examination is recommended. In these cases it was only after other conditions had been excluded by these methods that chronic appendicitis was diagnosed and that operation for this disease was advised.

Of the ninety-two cases in which operation was performed fifty-one were diagnosed microscopically as chronic productive appendicitis, twenty-seven as fibrosis of the appendix, eleven as chronic obliterative appendicitis and two as normal. Before proceeding to analyze the data it is important to define the terms used, to distinguish between chronic inflammation and fibrosis of the appendix, and to describe their pathogenesis.

Briefly, inflammation is the name given to describe the immediate protective and defensive local reaction to an injury. Its aim seems to be the prevention of further injuries by antagonizing the injurious agent and causing a solution and removal of foreign materials, which includes the dead tissue or cellular debris, it is distinct from the process of repair, although frequently the processes overlap and cause confusion by proceeding simultaneously in the same areas. Extensive injuries that cause metabolic disturbances in cells may not arouse any inflammatory reaction. Undue pressure exerted on cells may cause a slow destruction with little or no inflammatory reaction as for instance, in the hydronephrotic kidney. On the other hand, an injury which may

be scarcely visible, the death of a few cells and their coagulation into what might be termed a foreign body or the introduction of a foreign body may start an intense inflammatory reaction

The phenomena of acute inflammation are familiar, namely early contraction followed by dilatation of the vessels accompanied by flushing and local increase in temperature, the slowing of the blood stream, margination of the leukocytes, emigration of these cells, diapedesis and rhevis of the red cells and exudation of the fluid from the blood vessels, which causes edema, and coagulation of the fluid resulting from the action of thrombokinase-forming fibrin. These changes are followed by the destruction of the invading agent, the autolysis of the dead tissue and its liquefaction, partial digestion by leukocytes, partial absorption by the lymphatics and the repair of the gaps

Living cells possess the ability to assimilate nutrition, as evinced by an increase of protoplasmic mass. As the mass becomes larger, the absorbing surface increases in area, but not proportionately, and ultimately the surface is not sufficiently great to provide adequate nourishment. The division of the protoplasm and nucleus occur with the formation of the two similar cells to replace the old one

When an injury occurs to a tissue or an organ, a stimulus is furnished or an inhibition removed, which results in a more rapid division of the remaining uninjured cells in the attempt to provide an adequate amount of functioning tissue

The various tissues of the body have an inherent specificity of regeneration in contradistinction to the embryonal cells. This specialization is rigid except in the case of connective tissue, in which greater latitude exists. The rate of regeneration of tissue varies considerably, for example, the epidermis regenerates rapidly, while the central nervous system and striated muscle regenerate scarcely at all. Gaps formed in the latter by injury must be quickly filled in by some tissue which can restore continuity rapidly. Thus, because of the different rates and powers of regeneration of various tissues, local repair is sometimes carried out by the injured organ-substance itself, it is, however, more often carried out by the inferior material, connective tissue. But even though such patching occurs, there is almost always an attempt there or elsewhere to restore the original specialized tissue unless it has been entirely destroyed

The epithelium of the mucous membranes regenerates with remarkable ease and rapidity, growing out from the edges by mitotic division to cover smoothly any denuded area. The glands are reproduced from the remaining specialized cells

Connective tissue reproduces itself in great profusion by rapid sheetlike cell division. At first, these newly formed cells lie loosely in the replacement site, later, their cytoplasmic fibrils become arranged

more definitely in a parallel formation, and they become compact and so conspicuous that they often efface the other characteristics of the cells, the final result being the formation of scar tissue.

Smooth muscle has little tendency toward regeneration. Wounds resulting in loss of substance are healed by bridging with connective tissue which, after having passed through the stages just described, contracts and diminishes the size of the gap.

If an acute invasion by a pyogenic organism occurs in an organ such as the appendix, hyperemia, leukocytic invasion, destruction of the invading agent and considerable tissue, autolysis and liquefaction of the latter result. Debridement by partial leukocytic digestion and partial absorption through the lymphatics follows, and the gap is repaired. The mucosa may become completely regenerated, or some fibrosis may result. The submucous fibrous tissue increases. If the muscle walls have been involved, they show evidences of replacement by fibrous tissue.

If the process is not fulminating, if the protecting influences gain the upper hand, and if the irritation persists in a milder degree because it is not entirely neutralized or removed, the infection becomes chronic. If the invading force consists of organisms, and if the balance between invader and defenders is struck at such a level that the organisms remain and continue to develop at a slow rate, they irritate the tissue and the reaction continues to be manifest, instead of being polymorphonuclear, however, the characteristic cells are lymphocytes, plasma cells and endothelial cells. The reparative processes result in fibrous deposits and thickening. There is no redness or heat, but swelling may be present. The most prominent pathologic feature is the abundant formation of new connective tissue and the round cell infiltration.

The inflammation may be chronic from the beginning, as for instance in the case of the introduction of a foreign body into the tissues or as a result of infection by organisms which act slowly on the tissues, e. g. tuberculosis syphilis and actinomycosis.

It becomes apparent, then, that a distinction must be drawn between the terminal fibrosis of a single or of repeated attacks of acute inflammation and of a true chronic inflammation. A true chronic inflammation is characterized not only by the presence of the fibrosis, but also by the presence of lymphocytes, endothelial cells and plasma cells. The fibrosis of the acute attacks is a termination, an end-result, the battle is over, the reaction is completed and the irritant is no longer active. In the chronic inflammation, the process is still active, with the reaction in progress and the irritant still injurious to the tissues. Failure to distinguish between these two conditions has led to much confusion. It is incorrect to call a terminal fibrosis a chronic inflammation on the other hand one cannot deny the possibility of chronic appendicitis.

because terminal fibrosis has incorrectly been designated as this condition in many instances

In this study, the criteria on which the diagnosis of chronic appendicitis is based are distention of the capillaries with an increase in leukocytic content, the presence of eosinophils in the muscle bundles, fibrosis, particularly that seen between the bundles of the inner circular muscular layer, thickening of the serosa, small lakes of round cells, general round cell infiltration and increase in endothelial cells. These may be present in any combination. The sections of some appendixes show massive granulations of the serosa with typical granulation tissue of the kind commonly seen in the presence of chronic inflammatory reaction.

The sections in the photomicrographs show the pathologic alterations in the cells which take place in cases of chronic appendicitis. Figure 4 shows the section of an appendix taken from a child, aged 16. It might be said that a child of 16 has scarcely lived long enough to develop a chronic inflammation of the appendix, but it must be remembered that acute appendicitis is a disease of early life, and that where it is possible for an acute inflammation to develop, it is possible for the chronic condition to persist when the proper balance is struck between the invading and the defensive forces.

The cases illustrated by the photomicrographs are different from those classified as chronic obliterative appendicitis. The latter condition is characterized by replacement in greater or less degree of all the layers of the organ by fibrous connective tissue and the obliteration of the lumen by granulation tissue, which subsequently becomes organized. Scarring is predominant, and when the process is complete, signs of activity are not seen. Before the end-stage, however, activity may be noted. Eleven of the ninety-two cases in which operation was performed were of this type. All of the patients were less than 40 years of age, and all gave a history of repeated attacks of symptoms, but only four recalled having more than three attacks. The tremendous fibrous replacement in the cases in which there were only a few attacks and the fact that the patients were under the age of 40 do not support the views of Zuckerkandl<sup>1</sup> and Ribbert<sup>2</sup>.

It has been claimed that fibrosis may occur without previous inflammation. Ribbert<sup>2</sup> and Zuckerkandl<sup>1</sup> regard fibrosis as an atrophic retrogressive process associated with advancing age and particularly liable to occur in a vestigial organ such as the appendix. This, however, has been heatedly contested. Aschoff<sup>3</sup> affirms that fibrosis is evidence

1 Zuckerkandl *Anat. Hefte*, 1894, vol. 4

2 Ribbert *Virchows Arch. f. path. Anat.*, 1893, vol. 132

3 Aschoff, L. *Die Wormfortsatzentzündung*, 1908

of a previously existent inflammation Ribbert and Zuckerkandl, however, fail to reconcile the tremendous fibrosis frequently seen in appendixes of children and young adults with their view on the atrophic retrogressive changes related to advancing age. One of the reasons for this controversy is the difficulty in understanding why many appendixes which were removed in the course of some other operation, and which histologically showed marked replacement of the wall by fibrous tissue,

# KOSTER—APPENDICITIS

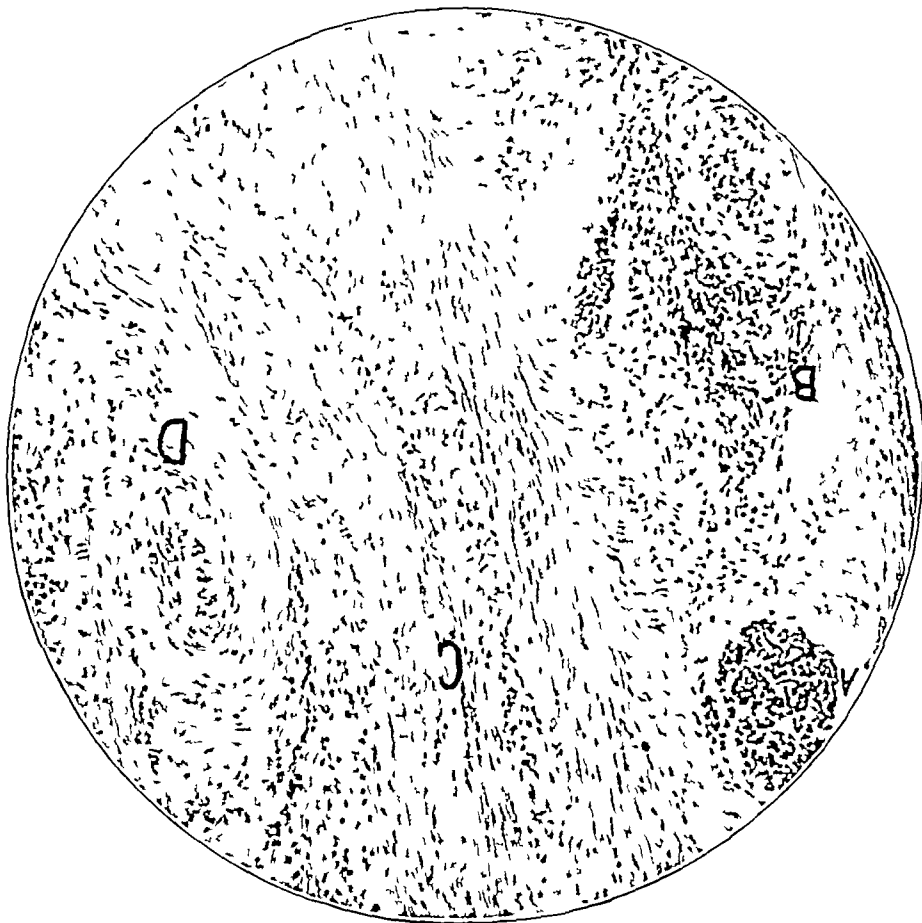


Fig 1—A section of an appendix, which is typical of the type of activity termed chronic inflammation,  $\times 90$ . A indicates a "lake" of round cells in the serosa, and B, a less concentrated infiltration of the serosa by similar cells. The inner circular muscular layer at C is undergoing replacement fibrosis and is infiltrated with small round cells. The submucosa D also shows marked fibrosis and round cell deposit

apparently did not produce disturbances which would point, clinically, to a pathologic organ. Williams and Slater,<sup>4</sup> in a study of appendices removed as a routine during pelvic operative procedures, report the frequent occurrence of fibrosis, although the patient had not com-

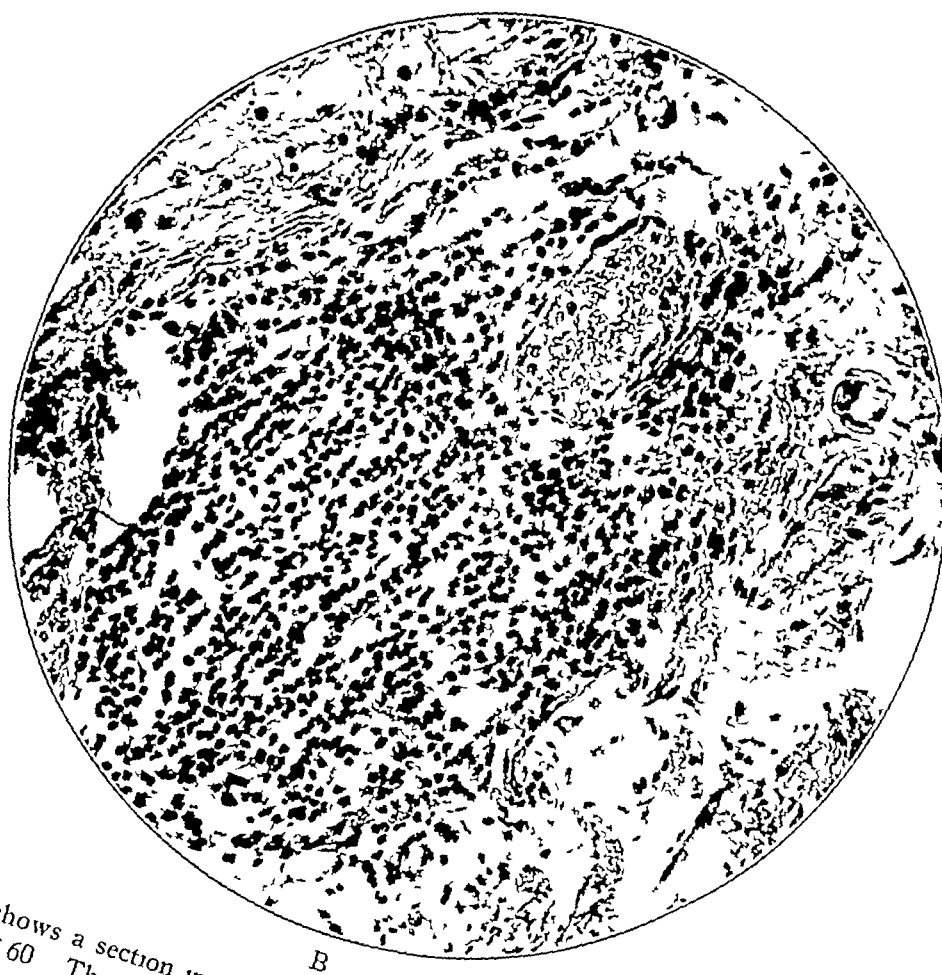
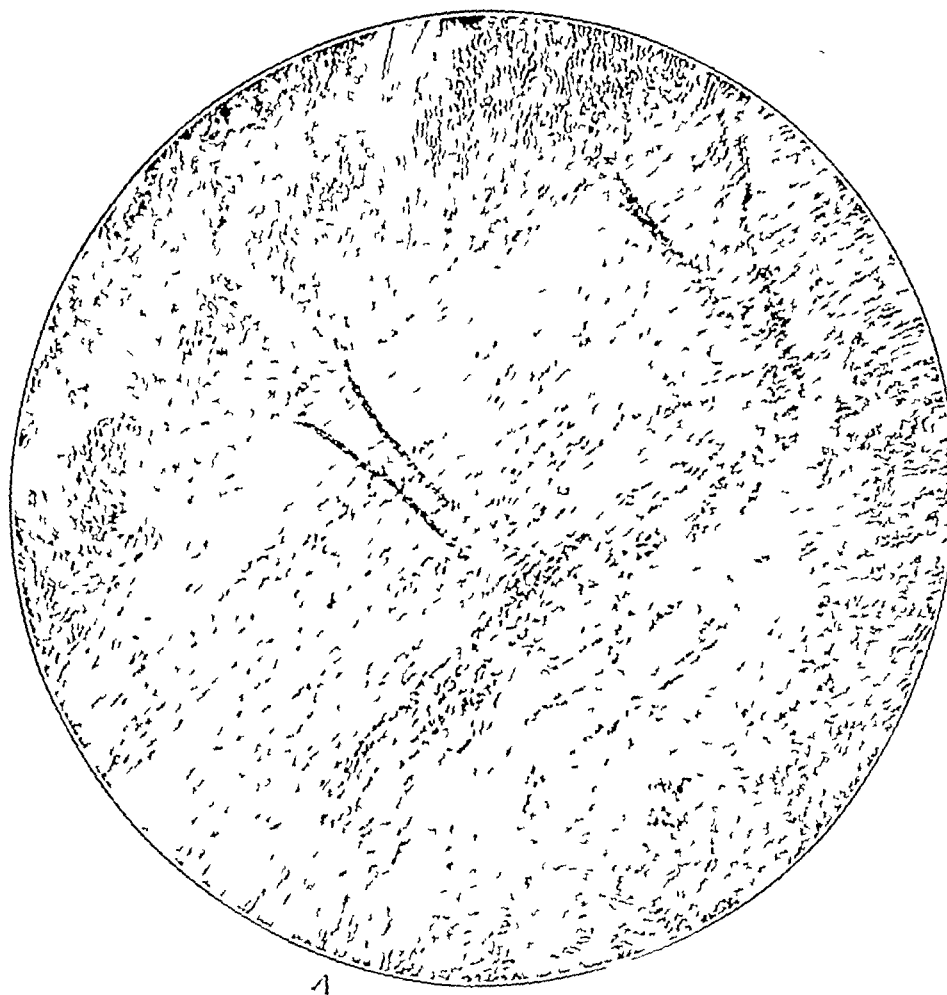


Fig 2—*A* shows a section in which the serosa is practically a mass of granulation tissue,  $\times 60$ . The muscle bundles are separated by fibrous tissue deposit. The higher magnification in *B* shows lymphocytic infiltration of the serosa which is characteristic of low grade inflammatory reactions.

plained of symptoms referable to the appendix. Another reason is that it may be difficult to understand how an appendix in which the normal structures have been almost entirely replaced by fibrous tissue can be productive of symptoms. These questions will be considered later.

Accompanying the appendiceal inflammation is a greater or less degree of periaepidicitis, i. e., an inflammatory reaction by contiguity of the adjacent intestines and peritoneum, accompanied by a serous exudate and some coagulation of the fluid-producing fibrin which may

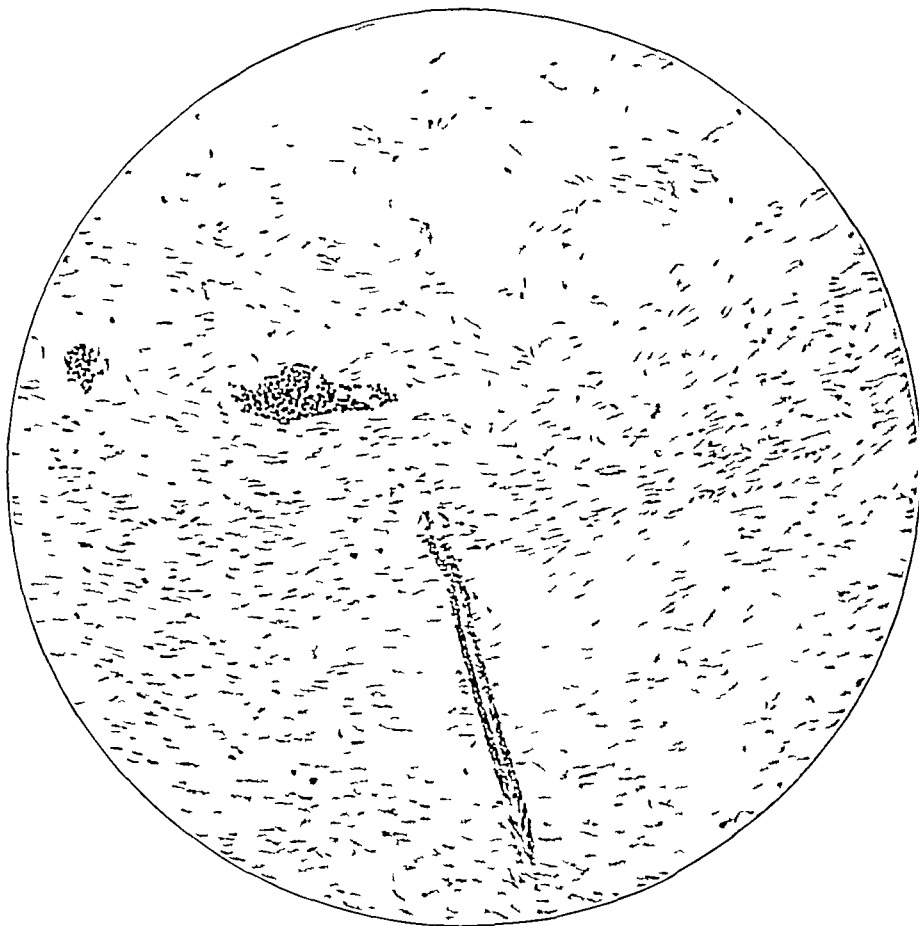
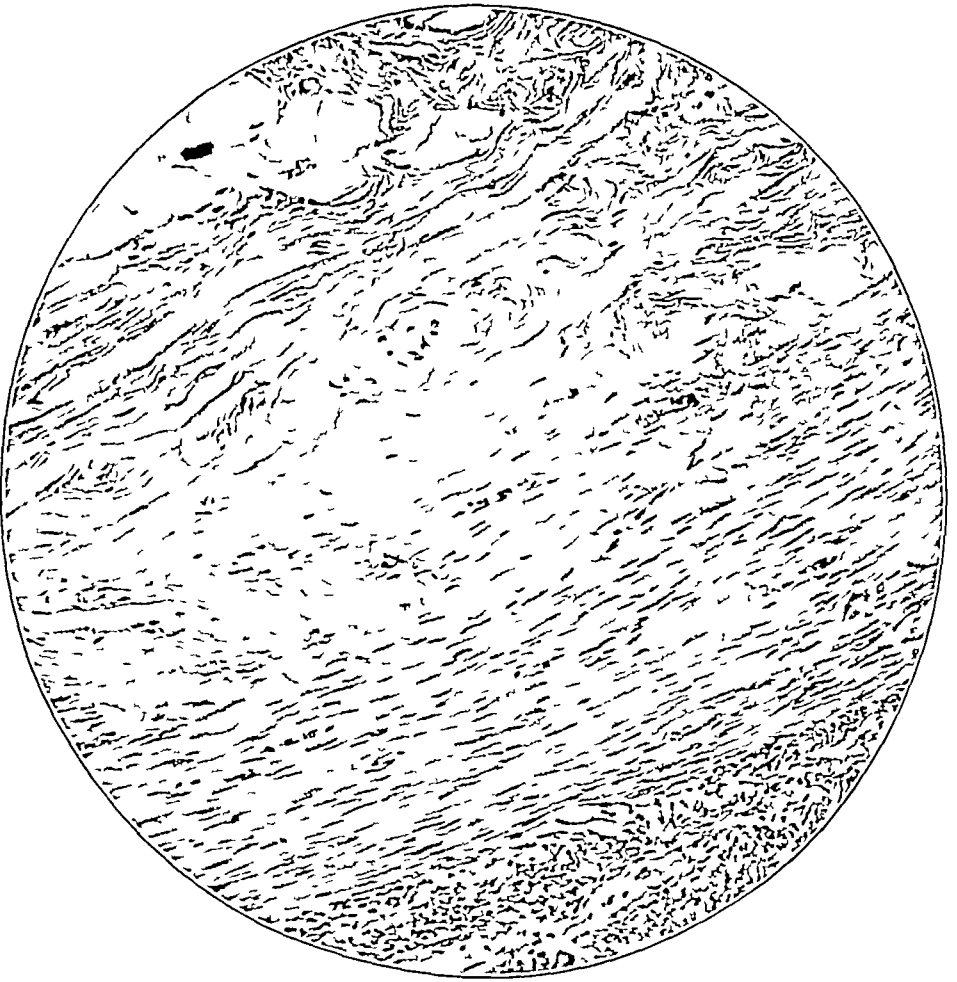


Fig 3—Marked fibrosis of the submucosa separation of the muscular fibres by connective tissue and lakes of round cells denoting a concentration of activity,  $\times 90$ . Sections of this kind cannot be classified as belonging to cases of terminal fibrosis. In the latter, the condition is one of scattering only, no activity is to be seen. The predominating feature is connective tissue replacement.

and frequently does act as a cementing substance to fix the appendix in all sorts of twisted positions to the cecum, ileum, parietal peritoneum bladder, fallopian tube omentum and other adjacent parts. Later granting defensive forces there is more or less organization of these adhesions with corresponding distortion of the appendiceal tube and limitation of the motion of the organ. The remaining adhesions may





A



B

Fig 4—*A* shows “granulation tissue” serosa, and marked connective tissue replacement,  $\times 200$ . The appendix from which this section was cut was removed from a child, aged 16. *B* is the same section under higher magnification.

be only fine, vellimentous and elastic, they may be thick dense and unyielding, or they show innumerable gradations between these extremes

The appendix is a cecal diverticulum formed of all the coats of the intestine. It hangs from the cecum, being attached by a peritoneal fold of varying size. The appendix hangs freely or is thrown into coils, depending on the size and shape of this fold. Normally, there is no

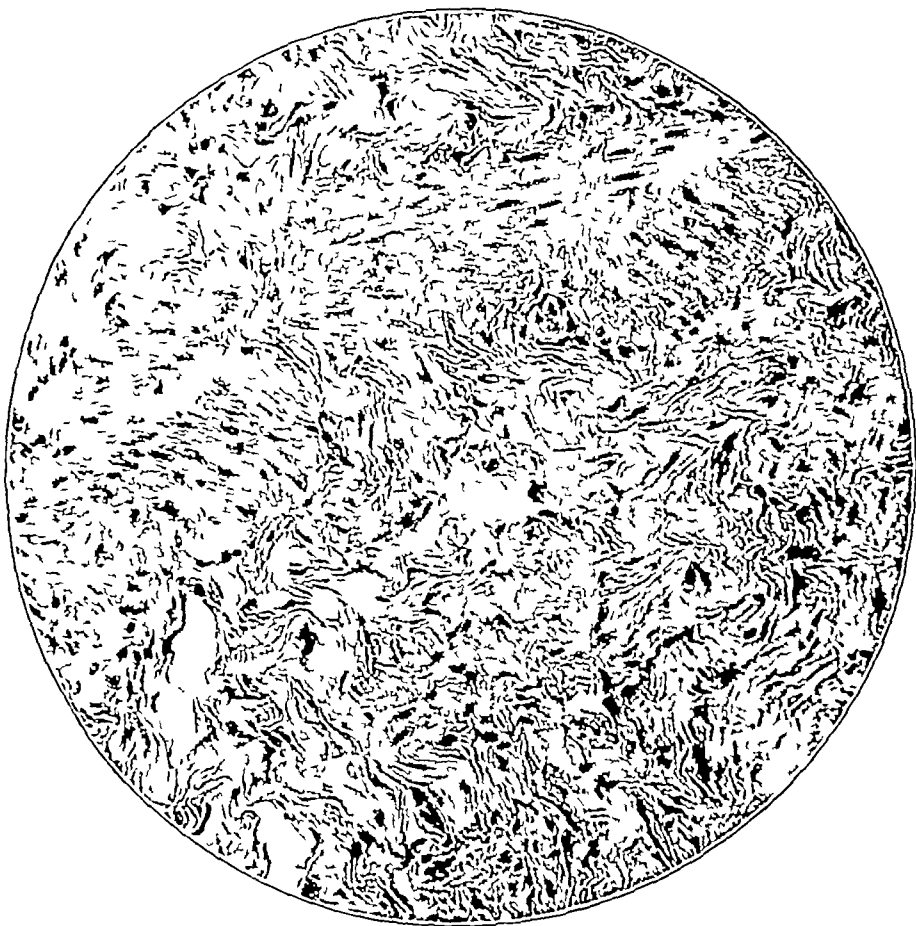


Fig 5—A high magnification of a section showing tremendous fibrosis and round cell deposit in the muscularis of the appendix of child, aged 11,  $\times 200$

kinking of the appendix, and the lumen remains patent throughout, insuring free drainage of the secretions and contents. When periapendicular adhesions occur, one of the most common results is kinking of the appendiceal tube which causes interference with free drainage of the contents. Stasis results, the severity of which corresponds to the degree of obstruction offered by the kink. This stoppage, in turn, provides the necessary factor for infection. Periapendicular adhesions frequently angulate or twist the meso-appendix so as to interfere mechanically with the venous flow such stasis further

favors the infection Jones and Evans<sup>5</sup> stress this point in discussions of the cause of appendicitis It is understood that the degree of infection is modified by other factors, such as, virulence and the number of invading organisms, amount of stasis, the suddenness with which the stasis is effected, the resistance of the host and other factors A sudden and complete obstruction, such as might be offered by the impingement of a fecolith against a well developed valve of Gerlach, would cause a severe appendicitis, with rapid and progressive involvement of all the coats The organ becomes a huge bouillon culture of bacteria which begin traversing the walls The walls quickly become so distended that the flow of blood is stopped, and gangrene and perforation soon result On the other hand, if the other factors were not modified, and if a mild degree of stasis were to be occasioned by partial obliteration of the lumen at one point as a result of a kink, a low grade inflammation might occur, because of the mechanical derangement, this inflammation would continue indefinitely

Thirty-nine of the ninety-two patients who were operated on had symptoms of less than one year's duration The longest period during which symptoms had existed was eighteen years All the patients had pain in the right lower quadrant of the abdomen

At operation, twenty-seven appendixes were found to occupy a retrocecal position This is at variance with the observations of Gladstone and Wakely<sup>6</sup> who note a retrocecal position of the appendix in 2,076 instances out of 3,000 necropsies The retrocecal position of the appendix in itself favors stasis and inflammation because of the tendency toward angulation at the base, particularly when the cecum is filled This point has previously been stressed by Jones and Evans<sup>5</sup> in a discussion of the mechanical factors causing appendicitis

Kinks of the appendix were found in eighteen instances These were noted only when they were so well marked that they could be considered to hinder the easy emptying of the organ The kinks were occasioned by adhesions of the appendix to the lateral pelvic wall the cecum or ileum Adhesions of the appendix were noted in fifty-four instances These were of all degrees and gradations, from fine, easily formed webs to well organized and, in one instance, calcified fibrous bands

A continued low grade infection such as that previously described results in continued replacement of the original wall by fibrous tissue Such an organ may produce several types of symptoms (1) symptoms referable to the organ itself, (2) symptoms resulting from parietal

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5 Jones and Evans, E J L Practitioner **114** 113 (Feb ) 1925

6 Gladstone, R J and Wakely, C P C Brit J Surg **2** 503 (Jan ) 1924

peritoneal irritation and (3) symptoms resulting from disturbances in physiologically and anatomically related organs

One of the most common manifestations of disease in an organ is a disturbance in function. The diagnosis of chronic inflammation of the kidney, for instance, is not dependent on the presence of pain in the loin. The ability of the kidney to maintain a more or less constant composition of the blood plasma is impaired when it is diseased and the study of the disturbance of its function by investigating the quantitative alterations in some constituents of the plasma and urine and the symptoms occasioned by such alterations offers the key to the diagnosis. This holds true for other organs also.

Most advances in physiologic knowledge relating to special organs have been gained by ablation of the organ and recognition of the resulting deficiency to the organism as a whole. The appendix considered as a vestigial organ, not having any ascertainable function or value, does not belong to the class described. Countless numbers of apparently normal appendices have been prophylactically removed in the course of another operation without any noticeable resulting deficiency. Its disorders cannot be studied from this point of view. Attention is not directed to its disorders by alteration in metabolism or by changes in special secretions of the body, but usually by the complaint of pain in the right lower quadrant of the abdomen.

The Auerbach and Meissner plexus of nerves found in the stomach and small intestines are continued down into the appendix and are distributed in a similar fashion. Coming from the solar plexus and consisting of both mediated and nonmediated fibers from the cerebro-spinal and sympathetic systems, they pierce the outer longitudinal muscular layer. Between this and the inner circular layer they form the plexus of Auerbach which contains sympathetic ganglions of the peripheral variety. Then the nerves pass into the submucous layer where they form the plexus of Meissner. From here, nonmediated fibers (in conformation with sympathetic fiber distribution elsewhere in the body) are distributed to the mucosa as periglandular and sub-epithelial networks as well as to the muscular tissue. Centrally, these nerves reach the solar plexus from which impulses may reach the gangliated cord through the great splanchnic nerves arising from the sixth to the tenth dorsal ganglions. Thus the pathway of a nerve reflex involving the appendix is through fibers in the superior mesenteric plexus to the celiac plexus through the splanchnic nerves to the dorsal ganglions and through gray rami communicantes to the spinal cord. Peristaltic movements of the intestines are initiated by irritation of the intestinal mucosa. Unlike irritation on the surface of the body stimuli normally supplied to the intestinal mucosa by food are not transmitted to the cerebral cortex. The former are relayed to the brain for

the protection of the animal. Experience has taught that the latter are not injurious. As a result, cerebral coordination not being necessary, the stimuli are side-tracked in the cord, and the reflex arcs necessary to stimulate muscle fibers to peristaltic action or glands to secrete are completed. The stimuli from severe irritation to the appendiceal nerves, whether as a result of pressure or of inflammation, reach the cord and cre-

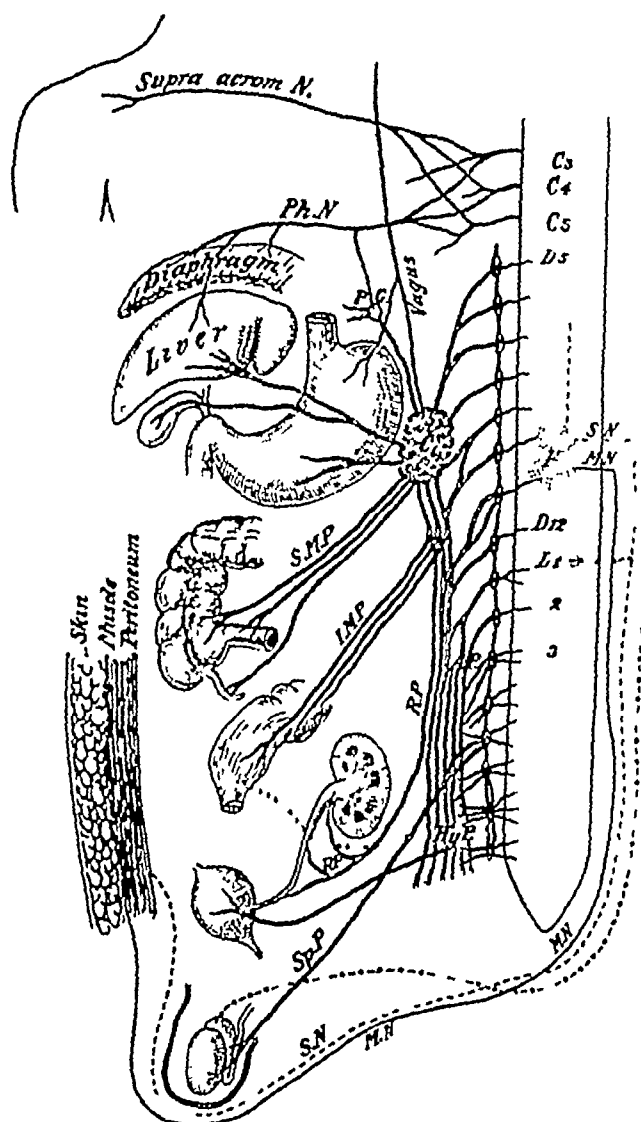


Fig 6—*Ph N* indicates the phrenic nerve, *P G*, the phrenic ganglion, *C*, the celiac or solar plexus, *S M P*, the superior mesenteric plexus, *I M P*, the inferior mesenteric plexus, *R P*, the renal plexus, *A P*, the aortic plexus, *H y P*, the hypogastric plexus, *S p P*, the spermatic plexus, *C*, the cervical nerve roots, *D*, the dorsal nerve roots, *S N*, the sensory nerves, *M N*, the motor nerve, and *F*, the area of stimulation in the cord

ate a zone of hyperexcitability at the level of entrance (fig 6). This affects the adjacent sensory fibers so that impulses that were formerly subadequate to cause sensation now become adequate, and since the cortical perception is interpreted in terms of peripheral distribution, the sensation of

Pain is appreciated at the sensory endings on the skin. When a severe stimulus is applied to a tissue of low sensibility which is in close central connection with a tissue of greater sensibility, the pain is referred to the latter rather than to the former. Through the sympathetic system, the spinal cord and the spinal sensory nerves the appendix is connected with a triangular area of the skin of the right side of the abdomen, the center of this area corresponds roughly to McBurney's point. The cause of this connection is the persistence in man of the segmental relationship between the cord, the skin and muscles, such as that found in primitive vertebrates. Irritation of sympathetic nerves resulting from inflammation of the wall of the appendix is similar to the irritation to the end-plates of sensory nerve caused by inflammation of the skin and subcutaneous tissue, in that the stimuli produced are of greater than normal magnitude. The stimuli of more than normal magnitude arising in the appendix may and do occasion pain on the surface of the body. Generally near McBurney's point, because the cerebrum interprets the stimulus as having arisen from the cutaneous rather than from the visceral connection. Similar irritation may be produced by the pressure of unstriated muscle. The pain resulting from the contraction of a tubular structure like the cystic duct or the ureter, in the attempt to move a calculus, are examples of stimulation of the nerve by pressure of muscle contraction. Similar cramplike pains may also be produced by vigorous peristaltic movements of the appendiceal wall in an attempt to extrude a fecolith into the cecum. The analogy between the appendix and the ureter or the appendix and the cystic duct is not far-fetched. In either instance, the appendix, a tubular organ having muscular walls capable of vigorous contractions as shown by the segmentation of ingested barium, is compared to other tubular structures. The cystic duct has a far inferior musculature, and yet the colic resulting from the cystic obstruction is undoubtedly severe. That severe colic can be initiated by forceful peristaltic contractions of a ureter in which there is a kink or a stricture is undeniable. The possibility of similar colic in similar strictures must be granted. Strictures of the appendix do occur, it is not uncommon to find appendices with grossly recognizable annular diminution of wall and lumen caliber, as a result of either an annular fibrosis (the sequel to a previous acute inflammation) or of a constricting periaappendiceal adhesive band. In either instance, hyperperistaltic waves are initiated to overcome the tendency toward stasis and colic results. Pitzman states that in all cases of chronic appendicitis there are strictures that are patent between attacks. Fecoliths are more common in appendices which have been subjected to previous attacks and which are linked by adhesions or distorted by scar tissue. They are also more commonly encountered in those having

ptosis of the abdominal viscera, and in young persons chronically constipated. McWhorter<sup>8</sup> reports an operation for a pelvic condition, during which he examined the appendix, he found that it was normal and without palpable fecoliths, and did not excise it. Fourteen months later, the patient began to have definite short attacks of pain in the right lower quadrant, lasting from ten to fifteen minutes, followed by a dull ache and tenderness for the remainder of the day. There was no relation to food. The attacks were rarely absent for more than a week at a time, and were worse when the patient was constipated. One and a half years after the first operation, a second operation was performed for profuse persistent menorrhagia due to changes in the uterine wall, at this time, the appendix was found free, but the long artery near the tip was noticeably dilated, and there was a fecolith one-half inch (1.27 cm) from the tip. He believed that this was strong evidence in favor of considering fecoliths as responsible for some cases of appendicular colic.

A considerable number of cases of so-called chronic appendicitis occurs in ptotic subjects. These ptotic sufferers have a dull steady, and sharp intermittent pain in the right lower quadrant of the abdomen. The colic is severe, and the patient is temporarily incapacitated. The excision of the appendix in these cases gives relief from the paroxysms of pain, but does not accomplish a cure, because it does not affect the concomitant conditions—ptosis, constipation and others—which have been important contributory factors in the production of the stasis necessary for fecolith formation, and for which the patient is often left untreated.

Pain may be produced by the tug of the appendix and adjacent cecum on the parietal peritoneum in those instances in which organization of adhesions has fixed the appendix and the cecum to the pelvic or abdominal wall after an acute inflammation with periappendicitis. Distention of the cecum or normal peristaltic movements during the churning process, especially if the ileocecal valve is competent, cause a tug on the adherent parietal peritoneum which produces pain. Experience with local anesthesia in abdominal operations has demonstrated a remarkable insensitiveness of the visceral peritoneum to cutting or burning, and, on the other hand, extreme sensitiveness of the parietal peritoneum to slight tugging.

The association of pylorospasm and gastric hyperacidity with chronic disease of the appendix has been thoroughly discussed in the literature on appendicitis. Much has been written on the frequency with which chronic inflammatory changes or the terminal fibrosis of repeated acute inflammations of the appendix has been found concurrently with chronic cholecystitis and cholelithiasis. It is not necessary to dwell on the reports of gastric hemorrhages cured by the removal of the appendix which

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<sup>8</sup> McWhorter, G. L. *S. Clin. N. Amer.* 4:713 (June) 1924.

histologically revealed little more than fibrosis of the muscular and sub-mucous layers with moderate lymphocytic infiltration. The names of Mayo, Moynihan, Deaver, Soltau, Fenwick, Sherren and others (men of wide experience and keen observation), have been associated with such reports. It has been exceedingly difficult in the past to imagine the possible relationship between the appendix and such remotely placed organs as the duodenum and gallbladder, but studies of the abdominal lymphatics have revealed the existence of morphologic connections which form a substantial basis for pathologic speculation. Reference is made to the work of Kodama,<sup>9</sup> who confirmed the existence of lymphatic connections (through the medium of the lymphatic gland situated at the beginning of the portal vein) between the appendix, duodenum, gallbladder and surface of the pancreas described by earlier workers. A direct route for the transmission of infection is thus established.

There is also a morphologic and physiologic connection between chronic appendicular disease and such conditions as pylorospasm or gastric hyperacidity. Stimuli from the appendix travel along the nerves accompanying the superior mesenteric artery to the celiac plexus which is a central receiving station for all abdominal viscera. From this point reflex arcs are completed with secretory glands or muscle-fibers of the appendix. When the stimuli are excessive both in number and intensity however, the impulses reaching the solar plexus radiate to other adjacent cells and complete reflex arcs through axons of the adjacent cells with for instance, the acid-producing cells of the stomach causing hypersecretion or with the muscle cells of the pylorus causing spasm.

Patients present themselves to physicians not because a pathologic diagnosis has been made, but because they experience pain or have what is manifest to them as abnormal reactions. They seek relief from their symptoms. These symptoms may be due directly to an organic lesion in the appendix, to functional derangements or to both together. Among the organic lesions are chronic inflammation, stricture, periaependiceal adhesions and kinks.

Colic similar in nature to ureteral or biliary colic may result from exaggerated peristaltic movements in the attempt to overcome stasis resulting from stricture or kinks or in the effort to expel a fecolith. Less severe pain may be occasioned in the cases of periaependiceal adhesions by the normal reverse peristaltic movements of the ascending colon, causing a tugging on the parietal peritoneum and thus stimulating the nerves in the subparietal peritoneal regions.

Acting as a focus an appendix which is the seat of a continued low grade inflammation may spread infection through lymphatic connections



(or through the blood stream) to the gallbladder, duodenal wall, pancreas and other organs

Through faulty radiation in the celiac plexus, impulses coming from appendixes such as those already described may be transmitted to nerve fibers which innervate glands or musculature in other organs

#### SUMMARY

This article has shown that dull aching pain or intermittent and colicky pain in the right lower quadrant of the abdomen may be referable to organic or to functional disturbances in the appendix, and from a purely pathologic basis it is not correct to group all the conditions of the appendix responsible for this pain under the heading "chronic appendicitis," nor is it fair to assume that unless appendixes show all the evidences of a chronic inflammation they cannot be the cause of the symptoms. It becomes evident that at least part of the basis for confusion and controversy has been the tendency to group a number of symptoms and to attribute their causation not only to one organ, but also to one type of lesion, namely, chronic inflammation, whereas in reality other etiologic factors may be involved. The term chronic appendicitis has not been applied to a pathologic picture by the average physician, but rather to a clinical picture, and in many of these cases the pathologist may not find any evidence of chronic inflammation, the symptoms having resulted from kinks adhesions and strictures. Until it will become possible to recognize a difference, clinically, between the symptoms produced by a chronic inflammation of the appendix and those produced by kinks, adhesions, strictures and other lesions, it is suggested that the term chronic appendicitis be discarded entirely by the clinician as a preoperative diagnostic cognomen, and that "appendicular colic" be substituted. The operative observations will furnish additional information for classification, and only the combined preoperative, operative and pathologic data will furnish the minimum requirements for a complete and accurate diagnosis.

It is understood that the term appendicular colic is satisfactory only as a working basis, as is ureteral colic, for instance, but at least it will have a definite meaning and a definite application.

The standardization of the criteria for the diagnosis of chronic inflammation is also an important necessity for the avoidance of further contradictions. As was mentioned previously, no two pathologists out of twenty questioned held the same views. This means that when the pathologist in Rochester says "chronic appendicitis," his colleague in Boston does not visualize a similar picture. The natural consequence has been confusion and controversy. With the acceptance of a definite criteria, such confusion will be avoided.

# PATHOGENESIS OF GOITER CONSIDERED AS ONE CONTINUOUS DISEASE PROCESS

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Much effort has been expended in the construction of a classification of the diseases of the thyroid gland which would be acceptable to the pathologist and surgeon. Each has worked largely from his own point of view. The result has been that the pathologist's product has been wholly inapplicable to the clinic and the practical man's product has paid scant attention to the requirements of scientific terminology. The most generally accepted classification divides goiters into the adolescent, the colloid, the nontoxic adenomas, the toxic adenomas and, finally, the exophthalmic type with or without eye signs. This classification has a certain advantage in that it emphasizes certain prominent clinical groups. It is faulty in that it suggests that these groups represent separate diseases, or at least, separate disease states. It is further at fault in that it employs pathologic terms of doubtful applicability and in part employs eponyms, always objectionable in scientific terminology. This combination is confusing and inaccurate.

In the investigation of any medical problem, the only class of persons with which one's theories must harmonize is the patients themselves. If they fit in a theory one need worry little about the opinion of other investigators. Though the following presentation is not in harmony with the results of other writers, it aligns itself with my clinical experience. In the attempt to correlate laboratory observations with the life histories of the patients among whom I have lived for a generation it has become more and more apparent that the goitrous disease is not a series of separate conditions, but a process the gradual progression of which one can foretell with as much accuracy as one anticipates the various stages of many other diseases, for example typhoid fever and syphilis.

I have presented this point of view in a measure in several previous papers, and it is my purpose now to treat the subject with greater attention to detail amplified by suitable illustrations which emphasize the various stages. This presentation is based on an intensive study of 1,000 cases in which the specimen, the slide and the case history were constantly at hand. The final results have been checked up as far as possible by a constant contact with the patients after operation until the present writing. This prolonged contact with the patient is necessary for in this way only is it possible to secure an accurate opinion as to what effect the goiter has had on the life of the patient. In my early practice I observed many goitrous patients who were not treated. This gave me a background with which to compare the life history of patients after modern treatment by operation.

Casual observation distinguishes two great classes of goiters. One class is the colloid goiter which, as the name indicates, is characterized by an excessive collection of colloid in the acini with the subsequent development of accessory (possibly compensating) acini often associated with a long line of various types of degeneration. In early life, this type appears as a more or less uniform enlargement that does not cause any considerable disturbance. Appearing in early life, it is called an "adolescent" goiter, there is no other excuse for the name. In maturity this gland becomes irregularly bossilated by the more rapid growth of certain areas. The development continues by successive remissions and exacerbations. After the increased growth is associated with pregnancy or some other periodic disturbance. In this connection it is interesting to note, the comparative rarity of this type in the male. When this bossilated state is reached, the term adenoma has been applied. This is most unfortunate, for in no sense is the term "oma" applicable. The development does not begin at one point and extend from thence as tumors do, but all parts of the gland take part simultaneously in the process. The disturbance is in no wise tumorous, but always functional, and the nature and degree of the functional disturbance can be read in the anatomic structure of the gland.

In the other elemental type, there is marked constitutional disturbance associated with marked activity of the gland. The characteristic clinical features are marked nervousness, loss of weight and a greater or less degree of metabolic disturbance. The goiters are then called toxic, a descriptive but noncommittal cognomen. If the patient was known to have a goiter previous to the onset of the symptoms, the term toxic adenoma is applied. If it is not known whether the patient previously had a goiter or not, the term exophthalmic goiter (Grave's disease), is applied because Graves was about the third man, and the first Anglo-Saxon, to describe the disease.

This toxic state is associated with cellular proliferation in the gland with or without actual papillary formation. It is a mistake to assume that the whole gland is made up of this type of structure. As a matter of fact, physicians who have published such pictures in many instances have been obliged to search their slides to find such areas. In doing this, the reader has been unintentionally misled. The larger part of the slide usually is made up of far less active cellular proliferation. True, in a few the larger part of the gland is made up of active gland proliferations with papillabearing areas, but these are rare. In the great majority, a part of the gland is made up of old colloid acini associated with the formation of new acini, with a greater or less number showing active cellular development resulting in papillation. Such colloid-containing acini are now said to be "lugolized."

The cause of the glandular increase is not known. Whether it is developed as a primary process in normal glands or whether the cells are spurred to activity by previous changes in the colloid or merely associated with them is not known. There is evidence of a previous change in the vast majority of cases. In some instances however when the entire gland is involved in diffuse proliferation, its origin in a previously normal gland cannot be disproved.

When a large number of exophthalmic goiters are studied, one finds only a narrow dividing line between the so-called toxic adenomas and exophthalmic goiter. In most cases, if one studies the life history of the patient carefully, the toxic type is an acute exacerbation of a chronic state rather than a new or distinct process. Instead of separating these goiters from old colloid, clarity is achieved by considering them as a variation or continuation of the process. Hence, all goiters may well be considered as stages and variations of a single thyroid disease.

Many cases of exophthalmic goiter of sudden development appear in patients presumably previously free from goiter. Much confusion has arisen because the patient's word is taken as to the date of the appearance of a goiter. When a patient has a cancer of the breast the size of a walnut and declares that the tumor developed from a bump from a broom-handle ten days previous, physicians are not misled but when a patient says that his goiter first began to develop a few weeks or months ago, the statement is accepted. Yet on examining the gland in the laboratory, old acini, newly developed acini and vascular and other tissue changes are found that must have required years to form. Of course many patients with obvious goiters never knew that they were so afflicted. The patient's statement, as to the duration of a goiter is therefore wholly valueless and must not be accepted. A careful microscopic study of the gland, on the other hand, often gives accurate evidence. A superficial study is not sufficient. The changes in the acini and connective tissue must be studied by specific stains, histochemistry must be brought to the aid of topographic pathology.

In conformity with this conception, therefore, the following groups are to be looked on as the various stages in the development of the goitrous disease rather than separate types. They are mentioned in the order of their occurrence.

#### COLLOID STAGE (ADOLESCENT GOITER)

Adolescent goiter, as the name implies is the goiter of early life. It is characterized by relatively large elastic often soft goiters usually symmetrical in form. Generally they do not markedly disturb the patient but the more I study patients with these early goiters the more I am in doubt as to whether or not they are ever symptomatic. The patient exhibits evidence of nervous hypersensitivity and generally a path-

rate that is somewhat augmented. Even from the earliest beginning, one should be reserved in calling goiters *innocent*.

Though these goiters feel uniform on palpation, a section of them shows a division into lobules (fig 1). This is, of course, only an exaggeration of the divisions in the normal gland.

Histologically, these glands show large acini filled with a homogeneous acidophilic colloid (fig 2). Even in this early stage, there is usually evidence of new gland formation in the interstitial cells and in the walls of the acini. A goiter made up wholly of large acini without any cellular activity is rare, in the 1,000 glands on which this study is

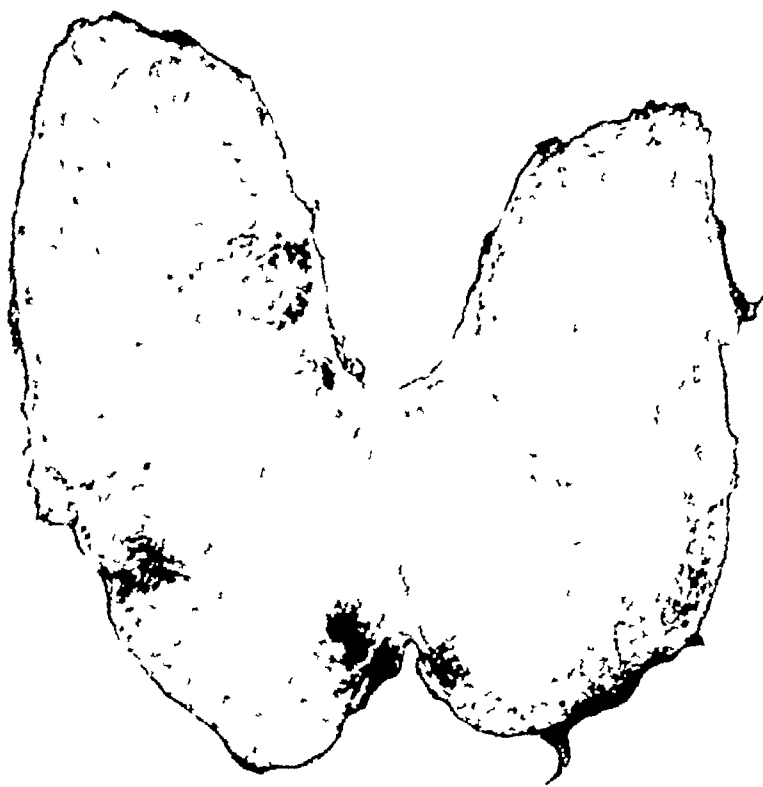


Fig 1—Simple colloid goiter from a boy, aged 14. The division into distinct areas by the fibrous septums is apparent.

based there is not one example of this type. It is true that areas are found which are so large that a photomicrograph may be made of them, but when the whole slide is examined, or slides from various areas, cellular activity will be found in some parts of the gland (fig 3).

Some writers, notably foreign authors, have confused these areas of acinal development with fetal adenomas, to which, of course, they do not bear any resemblance. The fetal adenomas are definitely encapsulated, and the acini are small, the cells are compact, and there is no colloid. These are true tumors, and, though often associated with goiter, are not an integral part of it, but have a life history of their own. Some writers have confused these tumors with the lobulations seen in any

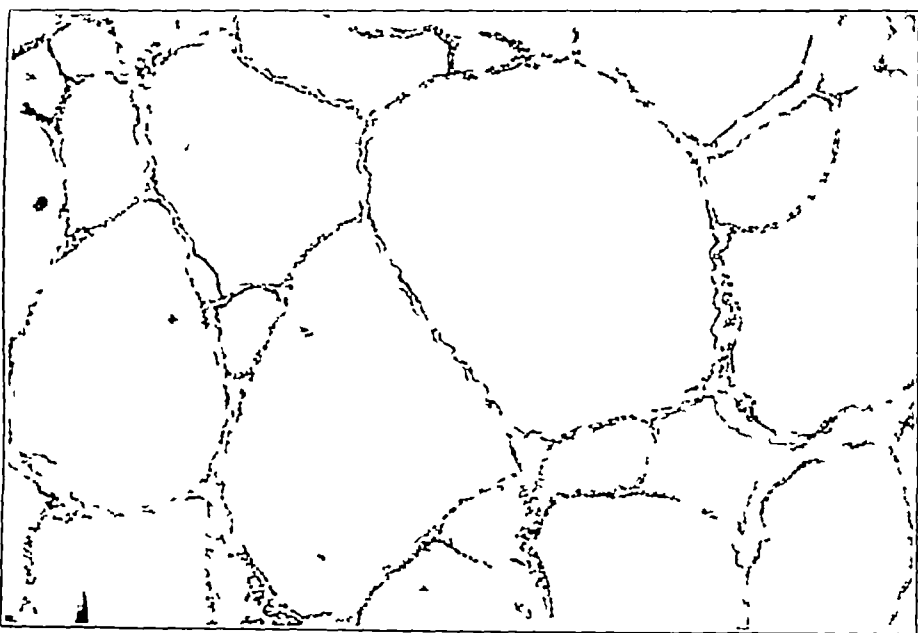


Fig 2—Slide from the gland in figure 1. There is little or no evidence of proliferation of the gland

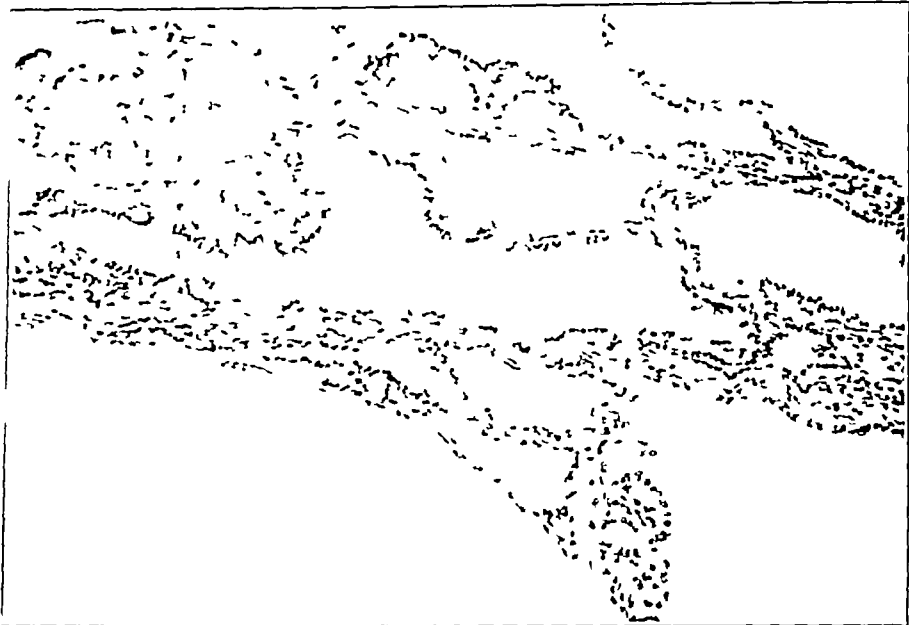


Fig 3—Evidence of gland increase. The photomicrograph is made from a section of a large goiter in a girl, aged 16

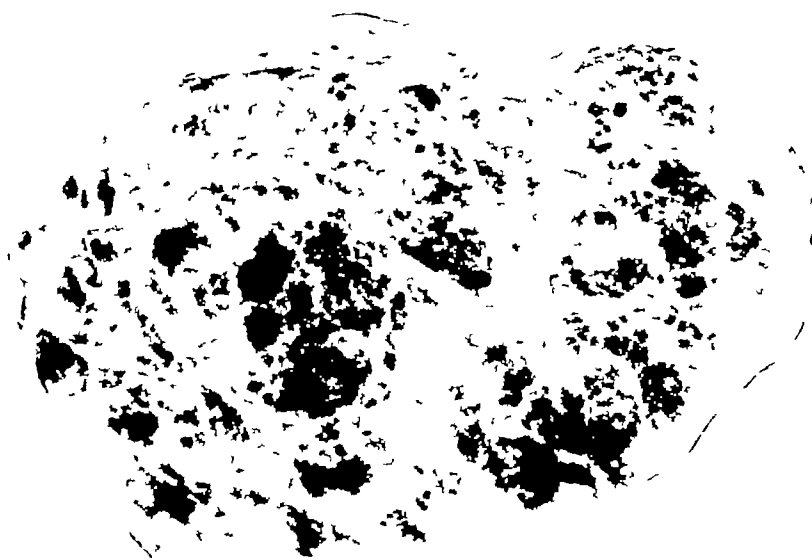


Fig 4—Moderately sized gland showing division into distinct areas by the fibrous septums

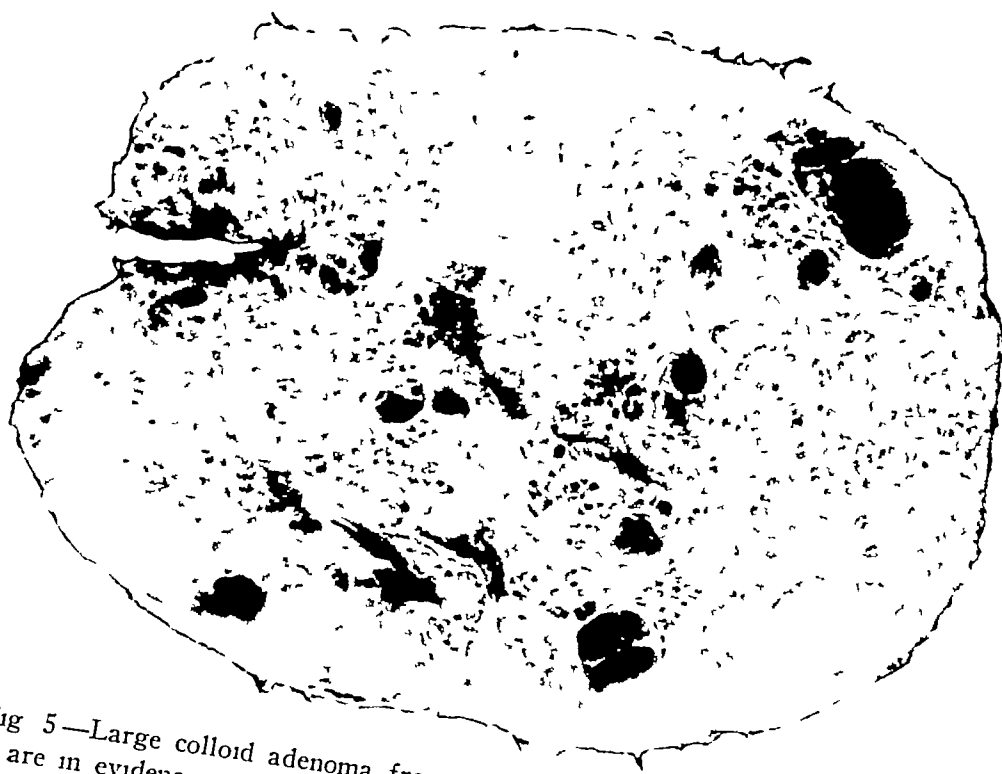


Fig 5—Large colloid adenoma from a girl, aged 20 Numerous good sized cysts are in evidence

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goiter of some age (compare figs 4 and 8). A short sojourn in the laboratory will quickly dispel this delusion.

As the gland develops, encapsulated areas are more apparent (fig 4). These areas are bounded by the natural septums of the gland. In this early stage, small cysts may be present (fig 5), as the disease advances the lobules may become more prominent, the cysts become larger and the fibrous septums more pronounced (fig 6). The entire gland may be made up of such nodules, while the exterior part of it is relatively smooth on palpation. The circumscribed areas appear only on cross-section. It is not yet, in common parlance, an "adenoma."

At this stage, the development of accessory acini may be active (fig 7). Cell masses without lumens appear in the interstitial spaces

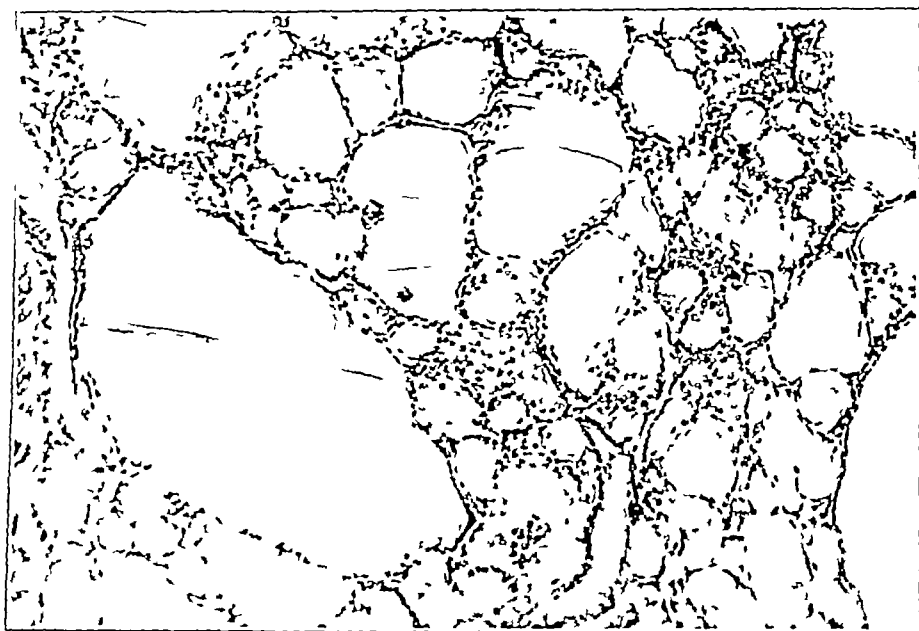


Fig 6—Microscopic section of a goiter removed from a patient, aged 30. The goiter was present fifteen years. The patient has recently shown slight nervousness. Clinically the gland was uniform in outline and elastic to palpation.

In this stage, the patients may or may not complain. Examination will invariably reveal some deviation from the normal, though disturbance of the metabolic rate is seldom one of them.

As a corollary to this stage it is necessary to consider the small firm goiters which Goetsch and I have called interstitial goiters. These are found in girls and young women. The glands are small and symmetrical and usually firm to the touch. It is unfortunate that these have been classed with goiters for they are usually associated with dysmenorrhea and intermenstrual pains. If they were regarded as they should



be, a part of a polyglandular condition, there would be a greater likelihood of properly interpreting the pain in the lower part of the abdomen, and it would help one to understand the nature of the mythical "chronic appendix." Microscopically, these glands show some increase in colloid, but it is usually unchanged. The acinar epithelium is flat. The interstitial cells are prominent, reminding one of the appearance of thyroid glands in children. In these there is little new gland formation.

Sooner or later in goiters of long standing, the nodules, apparent early, become larger, so that the capsule is protruded at certain points and the goiter becomes bossilated on palpation. It is now an adenoma,



Fig 7—Good sized uniform gland from a girl, aged 22. The goiter had been present eight years. The patient declared herself well. The pulse rate varied from 110 to 125, and there had been a loss of 16 pounds (7.3 Kg). She had become nervous and irritable. She was one of the author's office attendants and was under observation a number of years before and after operation. The new gland formation is apparent.

although the histologic structure has not changed. This irregularity of form is brought about by the development of some lobules more rapidly than others (fig 8). It is but an exaggeration of the earlier stage (compare figs 4 and 6). If one has a chance to observe a goiter over many years, one can note the appearance of new bossilations from time to time. In some cases, it seems that the formation of a new bossilation with each pregnancy becomes a milestone in the sands of time.

These bossilations owe their form to the restriction offered by the septums in the fibrous tissue, which characterize the normal gland, being heavier in some regions than in others. On section these bossilations are seen to be made up of many small lobules, each representing a lobule in the normal gland as shown in younger stages.

Histologically, one sees that the increase in size of the lobule, as well as the increase of the colloid content, is dependent on the development of small acini in the interstitial cells or within the walls of the old acini (fig 9). The cells lining the old acini are seen to be flat and endothelial-like, while those of the smaller ones are cuboid, suggesting that these glands are carrying on the function and really constitute a

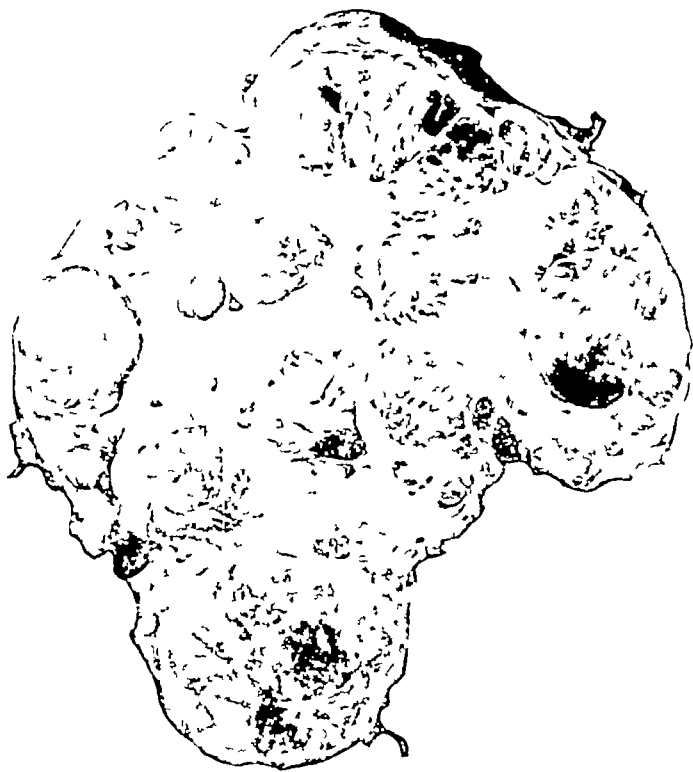


Fig 8—Bossilated goiter removed from woman, aged 35. She had long been nervous and irritable, but otherwise she complained only of pelvic disturbance.

The source of the new acini is unquestionably the interstitial cells and probably also the walls of the old acini. It is by this process that the goiter becomes lobulated. The large lobules are usually made up of many smaller ones. These smaller lobules may each undergo changes which are often degenerative, thus giving to the section a mottled appearance.

During this development, the patient is little disturbed. It is the stage of "innocence" and it lasts on an average sixteen years from the time the patient first knew she had a goiter. During this period the patient undergoes the toils and turmoils of running a family or wishing she had one, and bears the brunt of the give and take known in

domestic bliss, during which she is not always able to tell whether she is sick or just suffering from the joys of life. If her symptoms are studied carefully, periods of nervousness, loss of weight and rapid pulse will be discovered at some time during this stage of development of the goiter. Advanced cardiac disturbance may develop without exciting apprehension. Abundant experience has shown that in the majority of these patients examination will show a disturbed pulse and some disturbance in general health. A patient with a goiter of long standing, whether bossilated or not, is seldom symptom-free. There is little metabolic disturbance at this stage but at intervals loss of weight occurs in many cases.

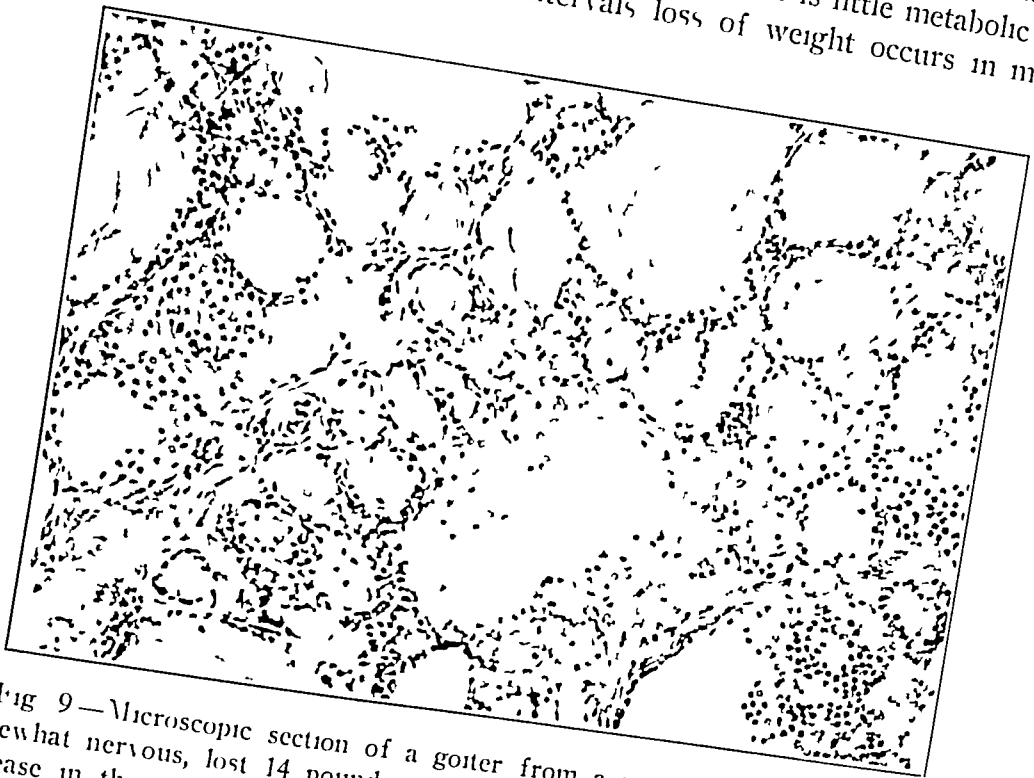


Fig 9—Microscopic section of a goiter from a woman, aged 47. She was somewhat nervous, lost 14 pounds, and had a pulse rate of 125. There is an increase in the small acini similar to that shown in figure 7, but more pronounced. She did not complain of the symptoms of toxic goiter. The foregoing data were obtained in routine examination.

#### CHRONIC TOXIC STAGE (TOXIC ADENOMA)

The chronic toxic adenomas must be distinguished from the acute toxic type, true exophthalmic goiter, which develops on long existing goiters. The toxic symptoms of the chronic stage develop insidiously requiring many years before the patient or her physician is aware that the goiter is the cause of the disturbance of her well-being. Sooner or later, the patient is compelled to recognize definite disturbance. When this stage is reached, there may not be a notable change in the size or outline of the gland or in its consistency, although patients sometimes say that the glands have become larger recently. As a rule, their complaints are not of any physical change in the gland but of

general disturbance. They become nervous, lose weight, become sleepless and have a rapid pulse. It is interesting to note that many patients take cognizance of their goiters when they learn that some friend has been cured of an innocent goiter or has died from the effects of one. Innocent goiters seem to be something like practical politics, a person suddenly awakens to the fact that he has been unconsciously suffering for a long time.

Since the operative removal of goiters has become a safe procedure and patients take note much earlier of the smaller ills due to the goiter it has made possible the study of goiters in the intermediate stages. It is only the more ignorant who are operated on late. It is safe to predict

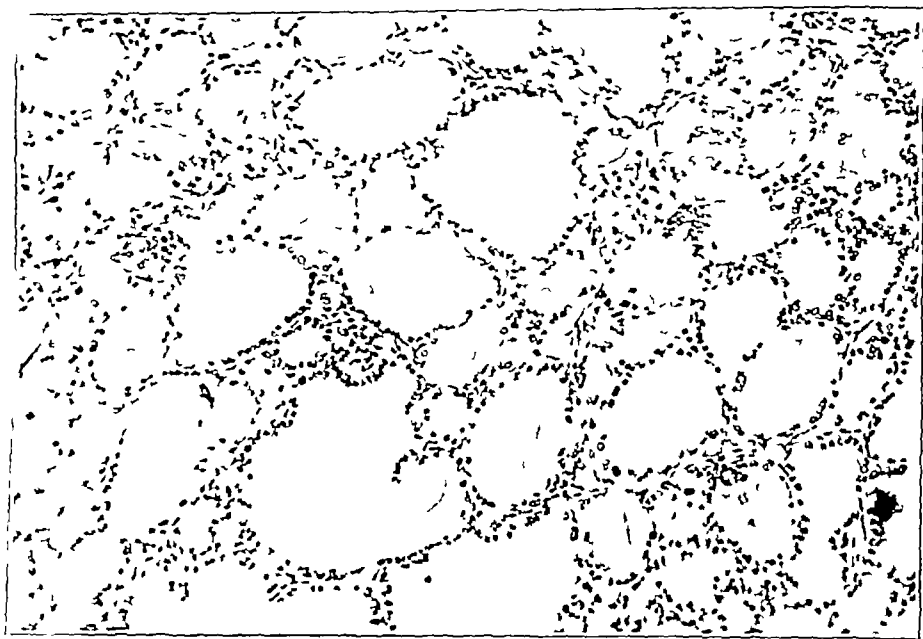


Fig. 10—Microscopic section of a good sized lobulated goiter in a patient aged 42. The pulse rate was 140, basal metabolic rate 44. There was a moderate loss of weight. The cells lining the acini are cuboid and there are many newly formed acini.

that subsequent statistics will show that the interval between the discovery of the enlarged gland and the time of admitted disturbance will be much less than sixteen years.

On section, the picture of toxic adenoma differs from that of the innocent stage of the goiter only in the greater vascularity. The lobulations may be less distinct because the connective tissue undergoes the same regression that it does in highly inflamed tissues; that is, it is less acidophilic. This results in friability of the gland in every operation. Often when the capsule is torn the gland substance comes out and has the appearance of exuberant granulation tissue. Histologically in the majority of goiters there is cellular activity either in the newly formed acini or in the epithelial lining of the

old acini, generally in both. The cells of the acini are cuboid, seldom columnar (fig 10), and many new acini are in evidence. Various areas of the gland nearly always still show the structure of the old colloid stages, often with extensive degenerative changes, the cellular increase is marked only in certain areas (fig 11). The goiter now has become a toxic adenoma, according to the generally accepted terminology.

In a few of these goiters there is little evidence of cellular activity, but everywhere there is a predominance of degeneration (fig 12). The cells are globular and show a disposition to loosen from the basement membrane, this is notable particularly in those cases in which the patient is not operated on and soon dies. It is difficult to say what part degenerative processes play in the less active cases. It seems to me that too

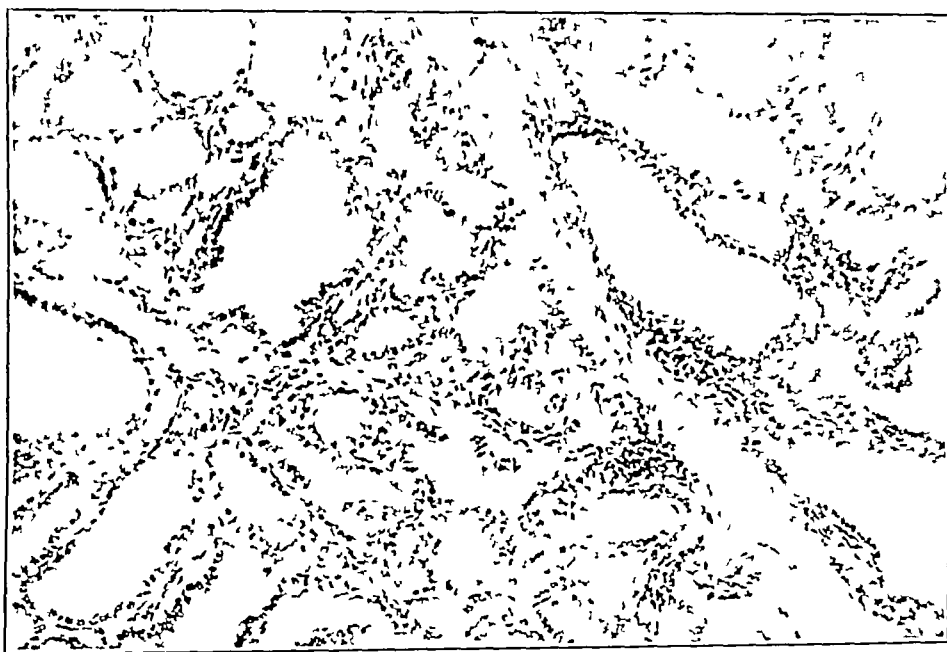


Fig 11—Microscopic section of a goiter from a patient, aged 41, with a clinical history similar to that in the preceding case. The loss in weight was 25 pounds (11.3 Kg). The pulse rate was from 130 to 140.

much attention has been paid to the epithelial changes and too little to the colloid. The epithelial proliferation in these old goiters reminds one of experimental epitheliomas which develop when the acidophilic character of the adjacent connective tissue is reduced by the injection of certain dyes. It is possible that the colloid changes first occur and that the epithelium develops in consequence; there is much evidence to this effect, which every pathologist with an eye trained in histochemistry can verify.

#### ACUTE TOXIC STAGE

In order to trace the relationship of the acutely toxic goiter to the colloid or adenomatous goiter it is best to study first the old colloid goiters which are slowly becoming toxic. The moderate gland prolifera-

tion is at once apparent. In the acutely toxic adenomas, that is those in which an exophthalmic goiter is implanted on an old colloid, this cellular proliferation is seen to be much exaggerated. Old colloid acini may be entirely filled with newly formed cells in some areas while in other areas the old colloid state remains. In the rapidly developing exophthalmic goiters occurring in thyroids not previously known to be goitrous the transition may be more confusing yet in nearly all such cases some areas are found presenting unmistakable evidence of a previously existing colloid change.

At the outset we are confronted by the following well established facts. Exophthalmic goiter is more common in younger persons, the toxicity develops more rapidly, and they have a more pronounced cellular

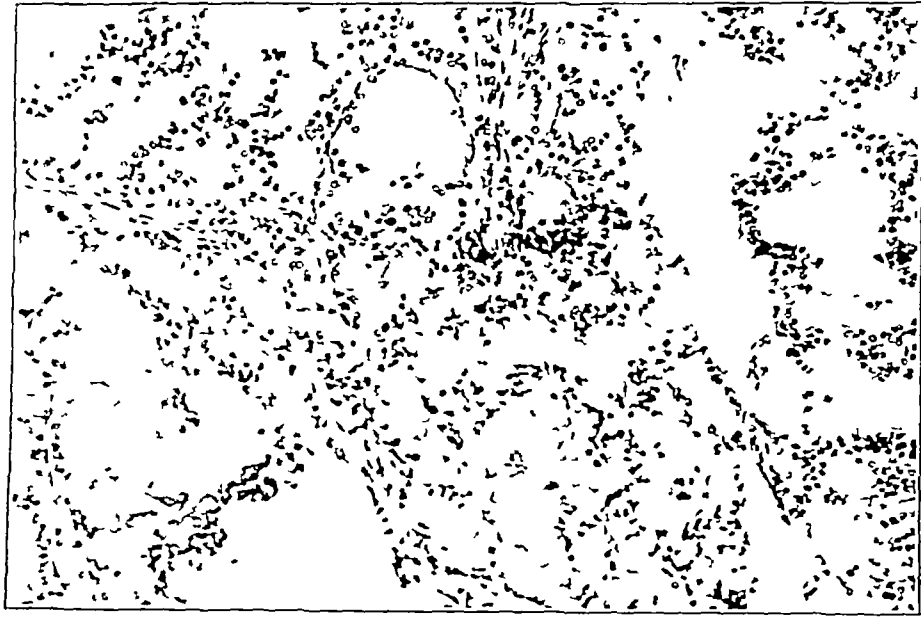


Fig. 12—Microscopic section of a goiter showing marked cellular increase but many of the cells have become loosened from the basement membrane. The patient, a man, aged 48, had had repeated attacks of nervous breakdown with loss of weight.

development. They develop in persons unconscious of having previously had a goiter and they tend more to a spontaneous remission. (On the other hand, it is equally well known that they may develop on long existing colloid goiters. When patients present themselves to the physician they say that the goiters are of short duration but on examination of the gland the condition is shown to be of long standing. Many of the patients have not discovered the goiter. There is a gradation between the mild and the severer forms. A patient with a goiter of moderate toxicity commonly refuses operation but after a time she returns to the physician in an extremely toxic condition perhaps with eye signs. Since patients

now present themselves earlier, those with eye signs are becoming rarer. Operation is performed before there has been time for the eye signs to develop.

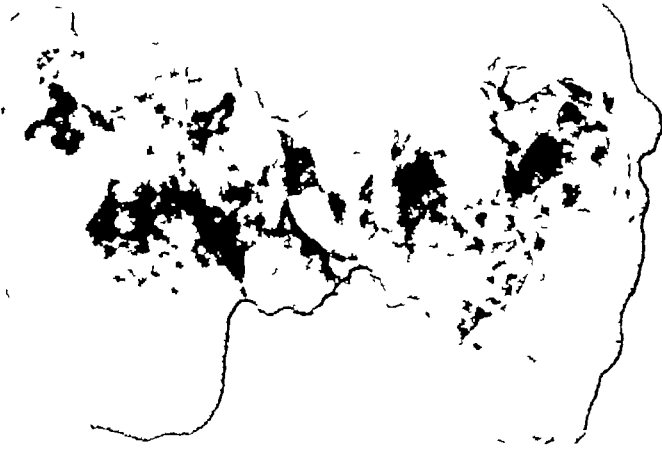
It was formerly the habit to describe dramatic beginnings to exophthalmic goiter. I confess with humiliation that for more than twenty years when patients related to me that their goiters dated but a few months back I accepted that date as the basis of my calculations. Perhaps they dated their troubles from the occurrence of some great emotional disturbance. No one, I dare say, who has suffered a great grief will have escaped the sensation of impending suffocation. Nothing obviously is better calculated to lead to the discovery of the presence of a preexisting goiter. It was only after an accumulation of hundreds of specimens which presented unmistakable microscopic evidence that the goiters were of long standing that it occurred to me that something could be gained by securing a careful history covering the period antedating the time of the alleged origin of the goiter. Since going further back than the suggested date in the history, it is uncommon to find patients with an alleged sudden onset of the condition who do not give evidence of disturbances antedating the time given.

It is not uncommon to see patients who present the symptoms of toxic goiter whose thyroid gland cannot be palpated even by the trained clinician. If the gland is exposed in these persons, however, it will be found to be enlarged, and will show characteristic histologic changes. Therefore, the history of the duration of a goiter is of little practical importance.

While a careful history and a study of the gland materially reduces the number of goiters of sudden onset of toxicity, there are some cases in which both means fail to establish a greater age for the goiter. In such cases, a careful search may fail to reveal any area not involved in active proliferation. On the other hand, I have seen the same process develop rapidly in goiters that I knew existed, although the patients did not. It seems to be an open question whether or not the proliferation characterizing exophthalmic goiter can develop on a previously normal thyroid gland.

Ignoring questions of history and considering only the clinical symptoms and specimens in hand, one finds that this type of goiter is often less lobulated, and that the gland may seem to be uniform in outline. On section, these glands are often gray, and when cut they have a firm feel resembling the sensation experienced when carcinomas are cut. This is due to the reactive changes in the connective tissue, and is not an expression of the degree of cellular development. Generally speaking, the younger the patient the more likely the gland is to be uniform. If these glands are examined carefully, however, while clinically uniform the cut section may show distinct lobulations (fig 13). On the other

Fig. 13—Photograph of the fresh gland in which the lobulations can be well made out. Clinically, the gland was uniform in outline and hard on palpation. The goiter occurred in a patient, aged 22, who had an attack of heart trouble five years ago with some loss of weight. The goiter was first discovered six months ago. The pulse rate was 125, and the loss in weight 29 pounds (13.2 kg.)



When the old bossiated goiters become "basedowified" there is not a great change in the topography of the gland. There may be a history of a recent enlargement. The chief change is that the gland becomes more firm, and it may become more sensitive to pressure. In those who have previously had uniform goiters, there may be an increase in size of the gland which is evident on palpation. This is particularly true of those which pulsate. The clinical symptoms of this type as contrasted with the more slowly developing toxic adenoma are characterized by greater intensity as well as more rapid onset. The pulse rate is rapid from 110 to 160. The skin is moist, and there is distinct tremor. There is usually a loss of weight, and the basal metabolic rate may be high. In many of the more intense types, eye signs are present in many one can predict that eye signs will develop. The aim of the surgeon should be to remove the goiter before the eye signs have had time to develop. While in general the presence of eye signs indicates the severer types, equally severe types are found without the presence of the eye signs. There is no essential difference clinical or pathologic between the patients with eye signs and those without.

Histologically this type is characterized by active epithelial proliferation. If one wished to employ an oncologic conception of the condition, good grade call these growths adenomas. Not in an active sense, but in likeness to a malignant adenoma is very close. The gland is very close to a malignant adenoma is very close.



forming new glands in the interstitial cells and in the walls of old acini (fig 14), as well as by the papillary projection of cells into the lumen of the acini (fig 15). Areas are found in which there are large acini which contain some vacuolated colloid, while the remainder is filled with papillated excrescences of columnar epithelium. This is particularly true of the glands of children. The cells may be cuboid or cylindric, in the active cases, the latter predominate.

In small glands, the greater part may be made up of such active proliferating cells. In those developing an old colloid, only certain areas are so affected. As many of the acutely toxic glands are found in early life, these glands are usually small, and there is not much evi-



Fig 14—Microscopic section of a bilateral, soft goiter. The patient had lost 50 pounds (22.7 Kg), had a pulse rate of 104 and showed marked loss of strength. The goiter had not been discovered before he entered the hospital. The cells lining the acini are cuboid and columnar in some areas, some masses of interstitial cells without lumina are seen.

dence of old colloid change. It takes many years to produce an old, lobulated colloid goiter. If one keeps in mind the age of the patient and the size of the gland, the histologic picture may be predicted. In the older glands, whether the patient is old or not, only areas here and there may show the active cellular proliferation, and papillated areas may be rare. Bossilated glands do not show masses of gland proliferation no matter what the clinical symptoms may be. In some cases of old goiters, several blocks of tissue must be cut before a characteristic area is found. It is certain, however, that if the symptoms are those of toxic goiter, areas of gland proliferation will be found, and if the symptoms are those

of exophthalmic goiter, that is, if eye signs are present, papillated areas will be found. When these facts are kept in mind the relation of the primary toxic and the "basedowified" adenoma is apparent. In rare instances there is evidence of gland degeneration without cell proliferation (fig. 16). These cases make me wonder whether or not too much emphasis is placed on cell proliferation and too little on degeneration in the interpretation of the very fondroyant cases. Evidence of degeneration is most apt to be seen in the rapidly fatal cases. In some of these, the size of the gland rapidly decreases as death approaches. It is as though the colloid had suddenly become absorbable and had overwhelmed the patient.

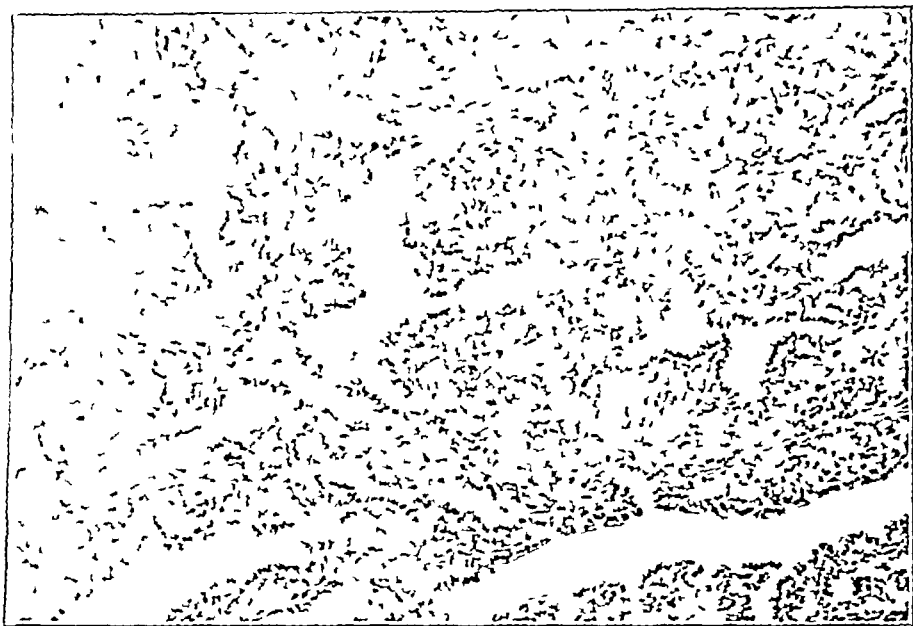


Fig. 15—Microscopic section of a goiter showing marked cellular proliferation with papillation into the acini which are free from colloid.

#### COMMENT

It is only by viewing the disease of the thyroid gland as a continuous process that the therapeutic indications become clear. Anatomic changes cannot be relieved by internal medication, it is only in the early stages that a complete cure by medication is possible. It is the age of the goiter that counts not the age of the patient. In the earlier stages evidences of disturbances are evident and perception of what they mean eventually lead to saves one from the error of considering them as a unit until irreparable damage has been done. Every complaint that a patient may have should not be ascribed to the presence of a goiter. Papillation of the neck should be the last act in the physical examination. If patients should not be the first to discover that the goiter is there then

So far as their tendency to destroy life is concerned, goiters, particularly the innocent colloids, should be compared with malignant tumors. It is as important to recognize an impending danger in its incipency in goiter as it is to recognize this in cancer. The fact that the development of goiters may require generations whereas cancers require years does not alter the gravity of the problem. Only surgeons are in a position to obtain the material which makes possible a correct understanding of thyroid disease, and consequently patients with goiter should be under the eye of the surgeon. Medical treatment during all except the early stages of goiter is as deadly as medical treatment for cancer. The analogy is not apparent, because the goitrous process is more insidious and kills without revealing the error of

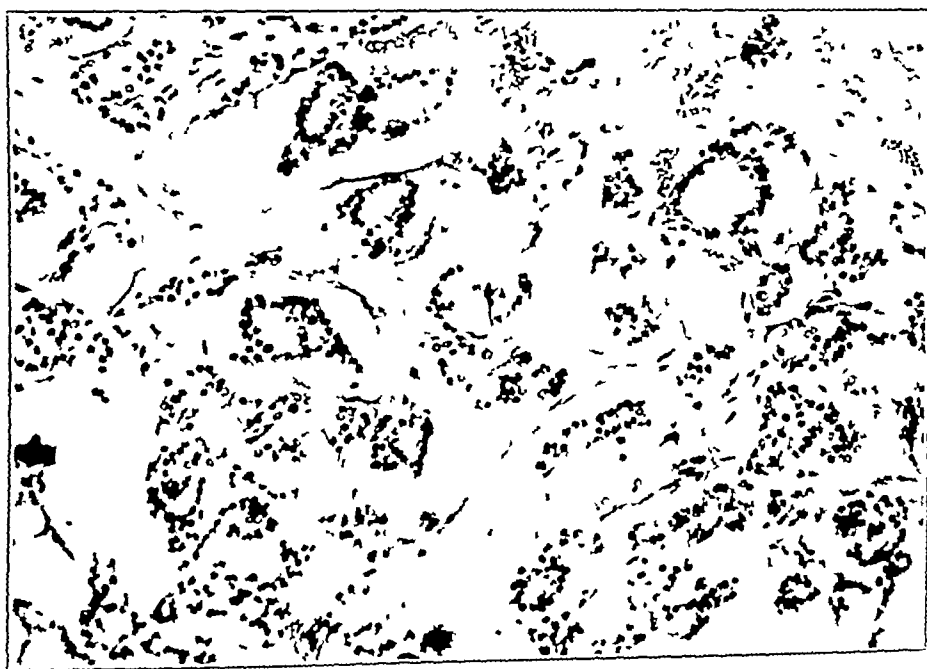


Fig 16—Microscopic section of a toxic goiter, showing a marked cellular increase. The cells are loosened from the basement membrane.

inadequate treatment. Patients living in this region who thirty years ago had innocent goiters have all died of cardiac failure.

#### SUMMARY

- 1 Colloid goiters early show evidence of new gland formation.
- 2 The formation of lobules within the gland begins with the first proliferation of cells.
- 3 Bosselated goiters are not different in structure than those uniform in outline, except that the process is more advanced.
- 4 The toxic stage is always associated with increased proliferation of the gland.
- 5 The so-called exophthalmic goiter differs from the so-called toxic adenoma in degree and in rapidity of development but not in kind.

# RELATION OF HYPERTHYROIDISM TO BENIGN TUMORS OF THE THYROID GLAND\*

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The pathologic significance of benign nodules or tumors in the thyroid body and their relation to states of hyperactivity of the gland are subjects concerning which there are profound differences of opinion and widespread confusion. The view most generally accepted up to the present time has been that all the tumefactions or nodules in cases of nodular goiter are adenomas, in the sense of true benign neoplasms, and that any anatomic or functional disturbances occurring in these patients are due to the activity and growth of the tumors. It is our purpose in this paper to present a brief analysis of 109 consecutive cases of nodular goiter with hyperthyroidism in which the patients were operated on during the last year, together with a review of 910 cases of hyperthyroidism and as a result of this study to present a conception of the pathologic and clinical significance of benign tumors of the thyroid gland which differs markedly and fundamentally from that held at the present time. In a recent study,<sup>1</sup> it was demonstrated that concomitantly with an

artificial or iodine remission in patients with fulminating hyperthyroidism or exophthalmic goiter a transformation from an extreme hypertrophy and hyperplasia to a resting or colloid state more nearly approximating the microscopic appearance of a normal gland occurred in the microscopic structure of the thyroid. This transformation was termed an involution of the gland and a terminology used to describe analogous regressive changes in the breast, ovary and uterus. Sections from the thyroid of seven patients were examined before, during and after the administration of iodine in sufficient dosage to produce an artificial remission so that in this way we were able to make a comparative study of the clinical course of the disease and of the histologic changes within the gland. The thyroid parenchyma which was removed and examined previous to an artificial remission brought about by no line revealed a marked diffuse hypertrophy and hyperplasia in all instances. The hypertrophy of the thyroid cells was similar in all the cases but a difference was noted in the type of hyperplasia encountered. In one type of hyperplasia this difference consisted mainly in the presence of

\*From the Thyroid Clinic of the Johns Hopkins Hospital  
I. Richthoff W. F. I. Involution or Regressive Changes in the Thyroid  
in Exophthalmic Goiter and Their Relation to Operation. *Arch. Surg.* 13: 351 (Sept.) 1926.

delimited areas or apparent lobules which contained large lacelike acini (fig 1) with papillomatous-like infoldings of the epithelium projecting into the lumen, but despite the increase in the size, the number of acini remained apparently about the same as in the lobule of the normal gland. In the other type, however, there seemed to be an increase in the number of acini. These acini were small, round structures in which little if any infolding of the epithelium was noted (fig 2). They were also regular in size and shape, and resembled somewhat the fetal acinus in structure and appearance. This difference in the hyperplasia of the parenchyma was also noted in 557 consecutive cases of exophthal-



Fig 1—Typical microscopic picture of hypertrophy and hyperplasia of thyroid gland from case of exophthalmic goiter removed before administration of iodine. Note papillomatous infolding of epithelium into lumen of acini. Reduced from a magnification of  $\times 176$ .

mic goiter in the Johns Hopkins Hospital. In the majority of cases, there were lobules representative of both types of hyperplasia, but in some, one type predominated throughout the gland as a whole. The large acini with papillomatous infolding were the type most frequently encountered. Mention is made of these distinct types in some detail because the process of involution seemed to differ to some extent, depending on the type of hyperplasia in which the process had its beginning. The remaining characteristic features of hypertrophy and hyperplasia of the thyroid parenchyma are too well known to require repetition here.

In the seven controlled cases already referred to the regressive state of involution was characterized by (1) a marked increase in the amount of colloid in its viscosity and in its avidity for stains (2) an increase in the size and regularity of the acini (3) a decrease in the height and size of the epithelial cells, (4) a decrease in the cystoph-



Fig 2—Histologic appearance of thyroid parenchyma in case of cystic degeneration. Note hypertrophy same as in figure 1 but there is a very marked decrease in the size of the acini and a marked increase in the amount of colloid. The epithelial cells are small acini without papillomatous infolding of epithelium. (H&E stain, magnification of  $\times 176$ )

mic constituents of the epithelial cells (5) an increase in the amount of the nuclei (6) a decrease in the lymphocytic infiltration (7) a decrease in the vascularity of the gland and (8) a proportionate decrease in the fibrous connective tissue separating the nodules and the

(figs 3 and 4) In some instances, the deposition of this fibrous tissue resulted in a veritable sclerosis of the lobule and even of the entire gland. The latter state was thus shown to be less active physiologically as well as histologically than the former one of hypertrophy and hyperplasia. This regression in the hyperplastic gland or involution was usually a diffuse process, which occurred to about the same extent throughout the gland as a whole. The degree of involution observed in the seven controlled cases, which was found also in 200 subsequent cases of exophthalmic goiter that had undergone an artificial remission after iodine, was reckoned as the average or normal degree of involution.

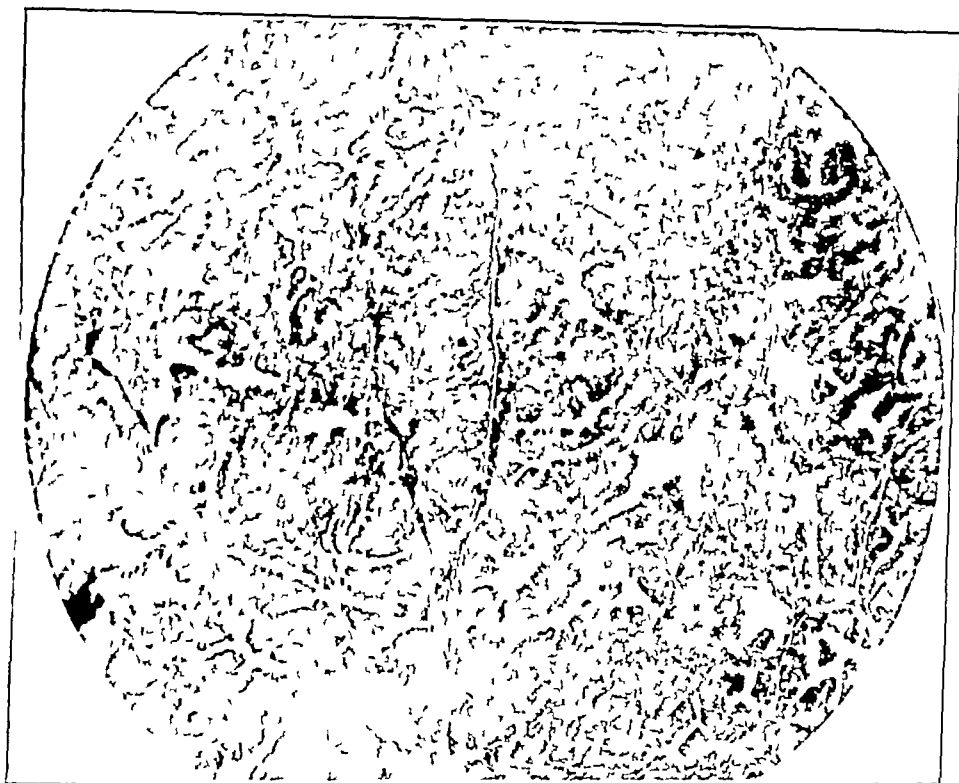


Fig 3—Section of tissue removed from thyroid gland of case of exophthalmic goiter before administration of iodine showing classic microscopic picture of hypertrophy and hyperplasia of the thyroid gland. Reduced from a magnification of  $\times 40$ .

that occurs during such a remission. In some lobules or areas, however, the process of involution was incomplete or absent, hypoinvolution, while in others it had extended beyond the average degree, hyperinvolution. The lobules or areas of hypoinvolution (fig. 5) appeared to be localized and encapsulated areas of hyperplasia which were composed of small, round acini. In and about these areas was an infiltration of small lymphocytes. They were areas in which either the involutional changes affecting the remainder of the gland had been resisted or (as Dr. W. G. MacCallum suggested) the disease process was beginning all over again. They

suggested histologically, the so-called diffuse and nodule areas of hyperinvolvement more common and of larger size, were designated as involutional bodies. They could be detected as nodules on the surface of the thyroid by palpation not only grossly, but also clinically, and when the thyroid as a whole became enlarged, following the deposition of colloid, these nodules also increased in size. On microscopic examination not only did they prove to be areas or lobules of the gland which had gone on to more complete involution than the usual degree occurring throughout the thyroid during

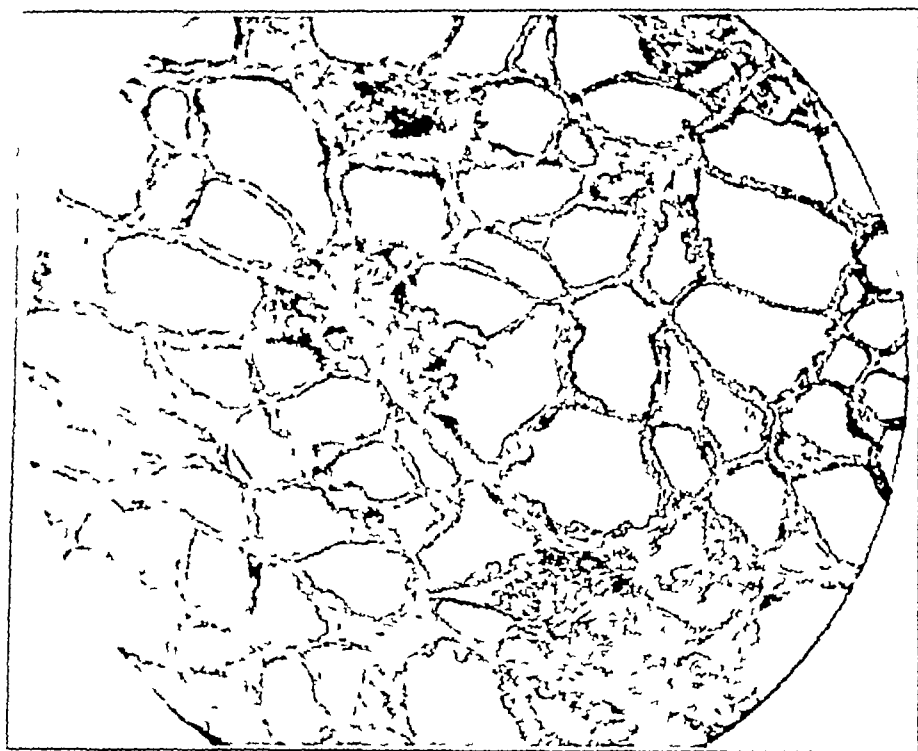


Fig. 4.—Section of thyroid from same patient as in figure 3 following the administration of iodine. Note involutional changes in the histologic structure of the gland. This is representative of the average degree of involution occurring in an artificial iodine remission. Reduced from a magnification of  $\times 40$ .

ing a remission, but in some a histologic regression that approximated an actual degeneration of the parenchyma was noted. Histologically these involutional bodies fall into three general groups, (1) those showing a formation of large epithelioid follicles containing colloid (figs 6 and 7) (2) those showing localized nodules of colloid areas of dilated colloid-containing acini (figs 8 and 9) (3) those indistinguishable from the so-called colloid adenomas (figs 10 and 11) showing areas or lobules in which the process of involution has been carried far beyond the average found throughout the gland, even surpassing the more complete involution of the thyroid.



type mentioned and approaching a state of actual disintegration of the parenchyma (figs 9 and 10) This extreme degree of hyperinvolution was usually limited to one area or lobule, and it was characterized by a breaking up of the acini, especially toward the center Thus, not only did the number of intact acini remaining for the lobule diminish, but those that had resisted the involution were separated by a larger

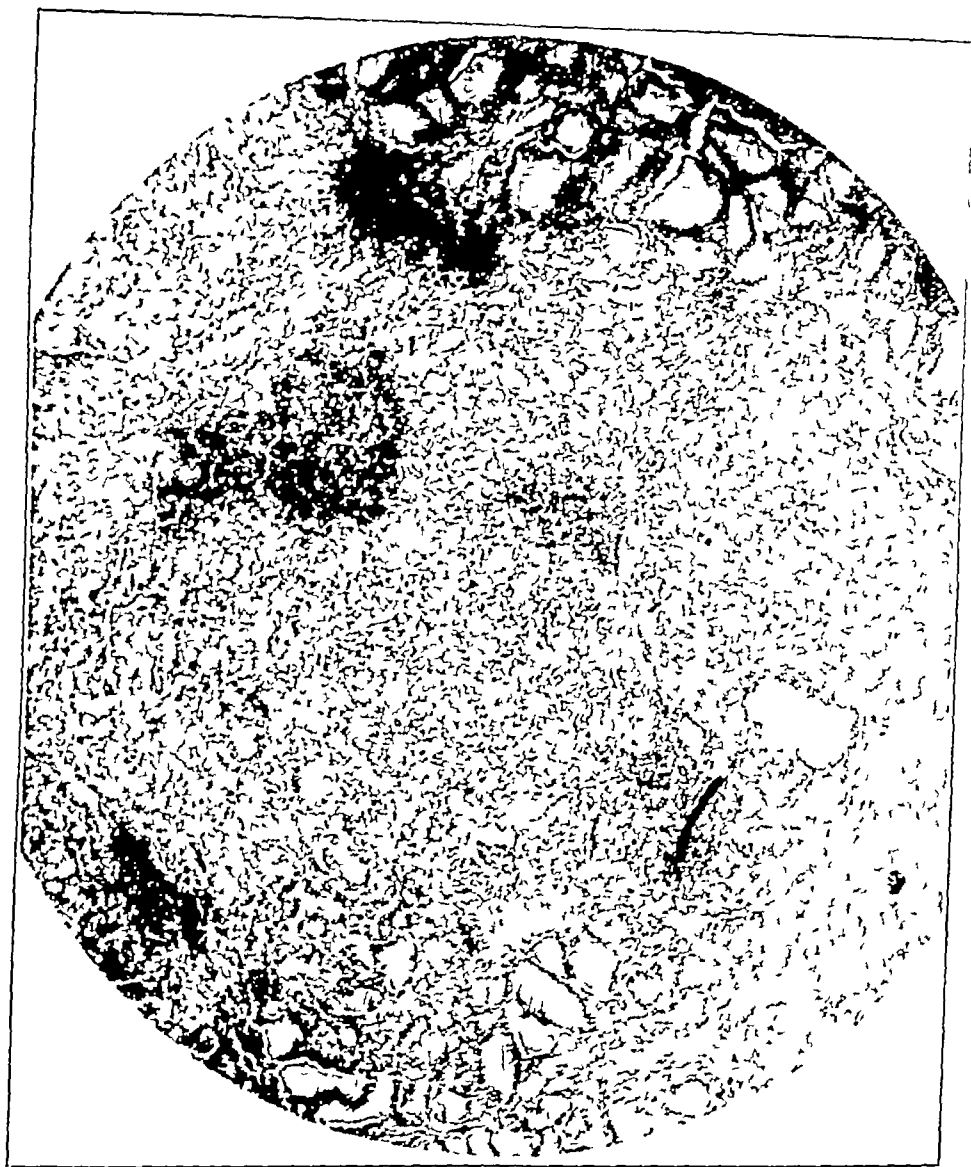


Fig 5—Average degree of involution which occurred throughout the gland as a whole can be seen in margins of photomicrograph In the center, however, can be noted an area containing many small acini or tubule-like follicles of cuboidal epithelial cells the apices of which abut on each other and in which the lumen, if any, is small Three areas of lymphocytic infiltration can be seen, the presence of which would suggest a localized area of histologic hyperactivity The area of persistent hypertrophy and hyperplasia or hypoinvolution seems to be confined to one lobule, the margins of which can be seen in the upper portion of the figure The intralobular stroma is delicate Reduced from a magnification of  $\times 40$

amount of stroma. This increase in the stroma resulted partly from an actual increase in the fibrous connective tissue and partly from a permeation of this connective tissue by the colloid which had escaped from the disintegrated acini. Desquamated epithelial cells could be found singly and in clusters throughout this stroma and here and there nuclei which had been extruded from the cells could be seen. The microscopic picture was one of marked histologic regression and degeneration. Here, as elsewhere, in the gland whenever involution had occurred there was an increase in the size of the area due to the excessive deposition of colloid. As a consequence the areas or lobules undergoing hyperinvolution were increased in size and volume to a greater extent than the surrounding parenchyma and this gave rise to a pronounced distortion of the acini of bordering lobules with their associated inter-

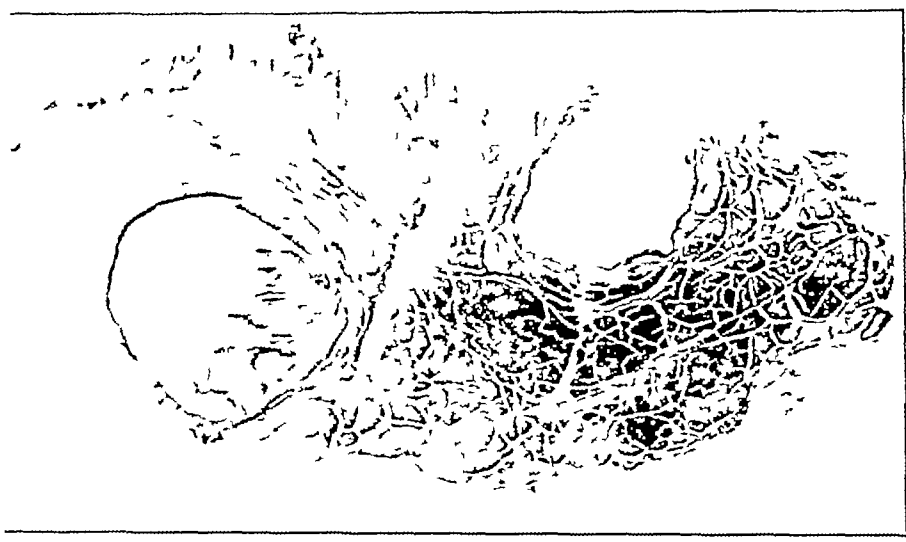


Fig. 6—Section across entire lobe of thyroid gland, intermediate of the patient with iodine and the occurrence of involution. The thyroid gland diffusely enlarged and smooth became nodular after treatment with iodine. Many large colloid cysts and localized areas of dilated follicles appeared some of which could be felt clinically. No compression of the gland about the large cysts as well as compression of the interlobular stroma. A fairly definite capsule has already been formed in the cysts of this figure. These demonstrate one type of hyperplasia reduced from a magnification of 27.10.

lobular and intralobular septums (figs. 7 and 8). This hyperplasia produced an apparent encapsulation so that the hyperinvolution became more sharply defined. The flattened acini and strands of fibrous stroma of the surrounding parenchyma resulted to the origin of the capsule. This hyperplasia of the capsule suggested strongly the so-called hyperplasia of adenomas the real phenomena and cysts (figs. 9 and 10).



Fig 7—Area of hyperinvolvement in the form of a large colloid cyst which developed in the gland during involution. Many of these cysts were present in this case. The average amount of involution occurring throughout the gland as a whole can be seen about the periphery of a figure. The beginning formation of a capsule about this colloid cyst can be seen in the compressed interlobular as well as in the intralobular stroma and the compressed peripherally situated small acini. The epithelial cells lining the cysts are much flattened, approximating endothelial cells. All changes point to an extreme involution or regression of the parenchyma. There is no evidence of hyperactivity of the tissue in either growth or function. Reduced from a magnification of  $\times 40$ .

of involutional body seemed to occur more frequently in the thyroid glands in which the parenchyma was composed of the small acinar type of hyperplasia already referred to (fig 2) whereas the glands in which the acini were originally of the large lacchke type containing papillomatous infoldings (fig 1) gave rise to areas of hyperinvolution made up largely of cysts and encapsulated areas of dilated colloid-containing acini. In the majority of the cases all of the three types of hyperinvolution or involutional bodies were observed although individual cases differed to some extent in the completeness of the artificial trans-

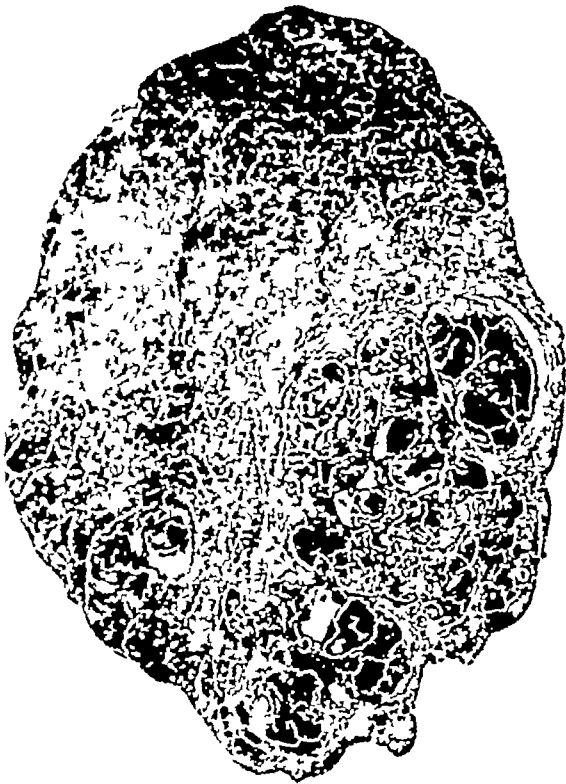


fig 8—Photomicrograph of section across entire pole of thyroid gland after treatment of the patient with iodine. Note areas of hyperinvolution which late macroscopically the so-called colloid adenomas. The thyroid gland and these areas has undergone average amount of involutional changes. Taken from a magnification of  $\times 16$

tion and also in the degree of involution. The latter is a rule of course paralleled the clinical improvement other factors such as an average of iodine given and the length of its administration being taken into consideration. Just as the reactions and reparative processes are exaggerated and overdone after an injury elsewhere in the body, so the return to normal in the gland in these lobules goes to a great extent. But it was observed that although these reactions are

involutional bodies formed localized palpable tumefactions, in general they maintained the structure of the normal hyperplastic thyroid parenchyma and did not show any such formation of new tissue as is commonly seen in a neoplasm, but rather regression and disintegration. Thus, these bodies differed in the microscopic appearance from a true benign neoplasm which always shows evidence of the formation of new tissue and more or less marked cellular regeneration.

In a further study of fifty cases of exophthalmic goiter in which spontaneous remissions and exacerbations had occurred and in which the thyroid had been partially removed during an exacerbation, it was



Fig 9—Areas of extreme hyperinvolution following the administration of iodine termed in this study as the third type that approximates degeneration, inequality in size of acini, extreme involution of epithelium and pyknotic nuclei, disintegrating acini, with the result that small clumps of epithelium are deposited in the abundant stroma. The stroma here is partly made up of colloid which has escaped from the acini due to this disintegration, this type of disintegration is frequently seen in areas of extreme involution. Reduced from a magnification of  $\times 67$ .

found that the gland was always nodular, and that these nodules could be palpated clinically as well as in the gross specimens. In the cases in which accurate and careful histories could be obtained, the information was elicited that the nodules had originally appeared after a nervous attack and had become enlarged after each successive exacerbation of the disease. In these cases gross as well as microscopic examinations

proved that the nodules were identical in all respects with the involutional bodies found after an artificial remission caused by iodine except that the latter were uniformly smaller than the nodules that developed after spontaneous remissions (figs. 11, 12 and 13). This difference in size is readily explicable if it is remembered that the areas of hypertrophy and hyperplasia associated with involution—and that they have been developed in a relatively short space of time in from two to four weeks, whereas the nodules resulting from the spontaneous remissions may be the products of not one but of many disease cycles



Fig. 10—Typical area of extreme hyperinvolution occurring after the depletion of iodine and involution. The histologic appearance in this certain one of definite disintegration. The stroma is markedly increased in appearance. The acini are small irregularly distributed and many have degenerated and become broken up. The follicles are scattered throughout the stroma in small groups. There is extensive extracellular colloid. The microscopic picture is one of extreme formation of new tissue. Reduced from a microscopic picture of 25

extending over a period of months or more after the depletion of iodine. Involutional bodies in these cases showed the same histologic appearance that had occurred in general throughout the gland. The removal of the parenchyma and when removed during the process of involution of the thyroid epithelium was found to be in the same manner as in hyperplasia (figs. 11, 12 and 13). In these cases the nodules were



Fig 11—Area of hyperinvolution that has occurred in the thyroid gland of patients undergoing spontaneous remissions in which a subsequent exacerbation had occurred when the gland was removed by operation, the histologic alterations observed in these cases following a spontaneous involution will be seen to correspond exactly with the involutional changes following an artificial remission or involution. Reduced from a magnification of  $\times 16$ .

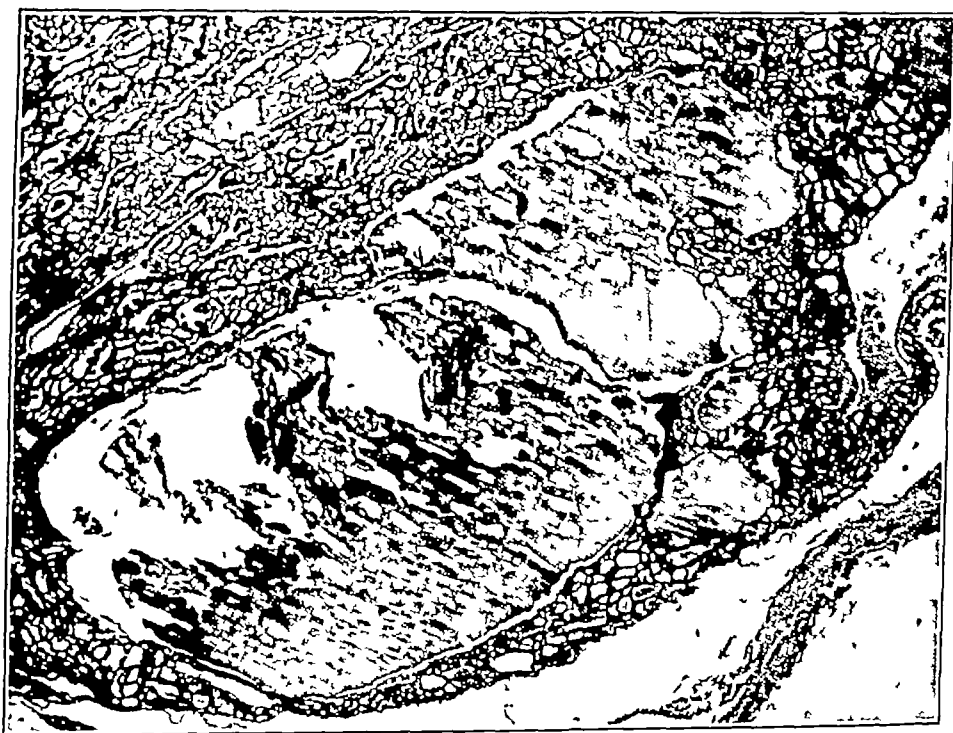


Fig 12—Area of hyperinvolution that has occurred in the thyroid gland of patients undergoing spontaneous remissions in which a subsequent exacerbation had occurred when the gland was removed by operation, the histologic alterations observed in these cases following a spontaneous involution will be seen to correspond exactly with the involutional changes following an artificial remission or involution. Reduced from a magnification of  $\times 16$ .

of dilated colloid-containing acini there was a tendency for the epithelium to undergo papillomatous infolding during an exacerbation of the disease (and probably in each exacerbation) followed by a further ballooning out and distention due to the deposition of colloid accompanying the involution associated with a spontaneous remission (figs. 12 and 13). In the lobules or regions of extreme hyperinvolution the functioning epithelium was relatively and actually reduced during remission, and there was marked fibrosis toward the center of the lobule (fig. 11). Therefore accompanying an exacerbation in this type of involutional body there was a peripheral zone of intact hypertrophic

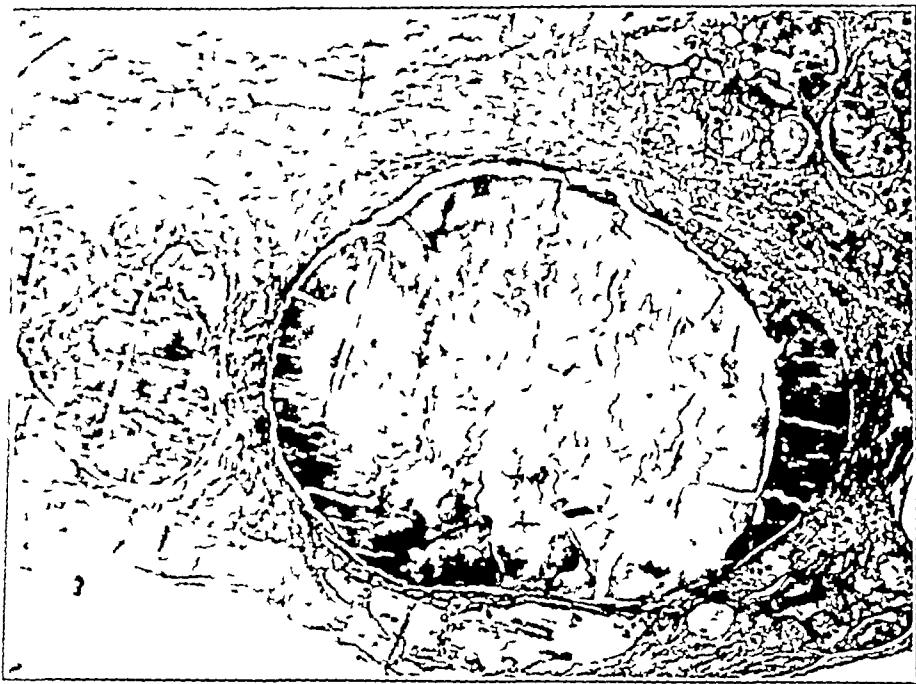


Fig. 13—Area of hyperinvolution that has occurred in the thyroid.

patients undergoing spontaneous remissions in which a specimen

had occurred when the gland was removed by operation. In these

observed in these cases following spontaneous involution. The

respond exactly with the involutional changes following an

involution. Reduced from a magnification of 10

and hyperplastic acini which become more sparse

by the substitution of fibrous tissue is one appearance

lobule. The peripheral zone of colloid hyaline

associated with the exacerbations was in the

gression or degeneration during involution

The intra-acinar colloid in these areas

the greater the number of remissions

involutional bodies will be seen



distinguished from the actual growth of a true neoplasm. Although these areas of hyperinvolution can be detected clinically as tumors, they are not true neoplasms or adenomas, because they have been observed to occur and develop during an artificial involution of the thyroid gland following treatment with iodine as well as after a spontaneous clinical remission. They also present throughout the microscopic characteristics of regression, disintegration or degeneration, and not of regeneration, with increased growth activity or actual increase of new tissue as in a neoplasm. Representing as they do regressive sequelae of a previous hypertrophy and hyperplasia of the parenchyma, the involu-

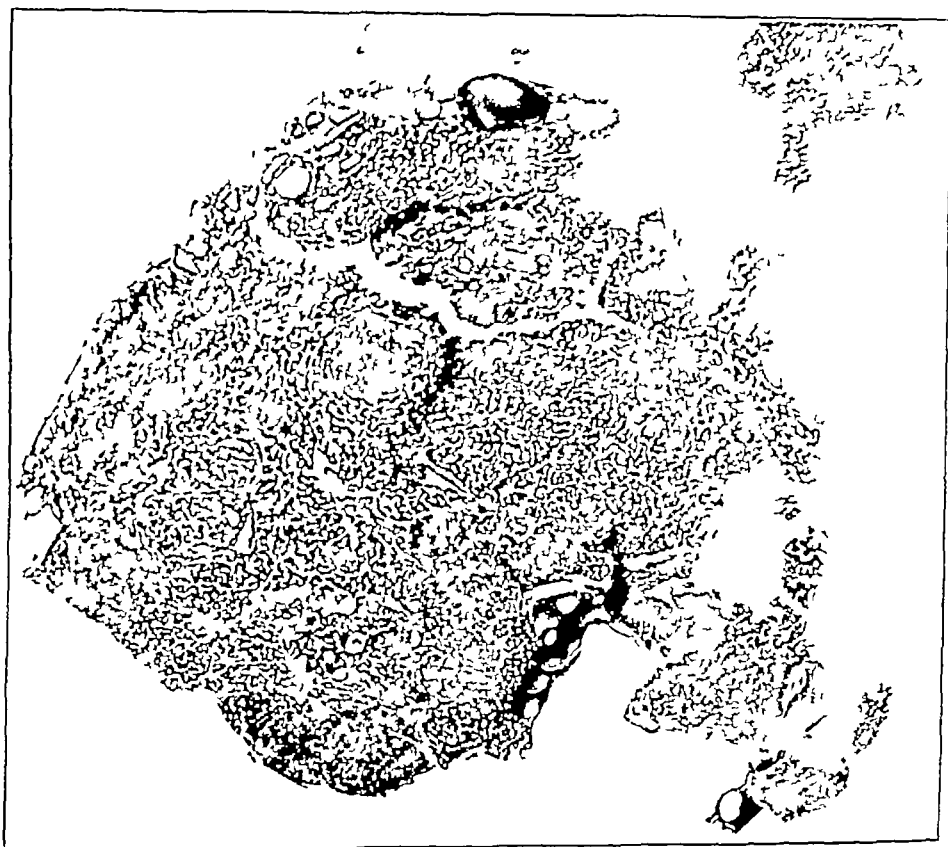


Fig 14—True benign neoplasm of thyroid gland. Histologic pattern is unlike that of normal or hyperplastic thyroid parenchyma. The epithelial elements are in anastomosing columns. Bizarre-shaped acini are near the periphery. Reduced from a magnification of  $\times 8$ .

tional bodies still maintain the structure of the normal gland parenchyma to a large extent, and, as shown in those cases undergoing spontaneous remissions and exacerbations, they become involved in the generalized hypertrophy and hyperplasia supervening throughout the gland as a whole during a recurrence of the active phase of the disease. A true benign neoplasm (adenoma) does not undergo hypertrophy and hyperplasia in sympathy with the remainder of the gland in which it has grown.

It can, therefore, be concluded that associated with atypical and spontaneous remissions in cases of extreme hyperthyroidism or exophthalmic goiter, nodules or clinically benign tumors are formed during involution of the gland, these are not true neoplasms but they are composed of hyperinvolved and disintegrating parenchyma that has undergone histologic regression

#### NODULAR GOITER ASSOCIATED WITH HYPERTHYROIDISM

The striking and rapid changes of the histologic structure in the thyroid gland and the production of involutional bodies which occur during

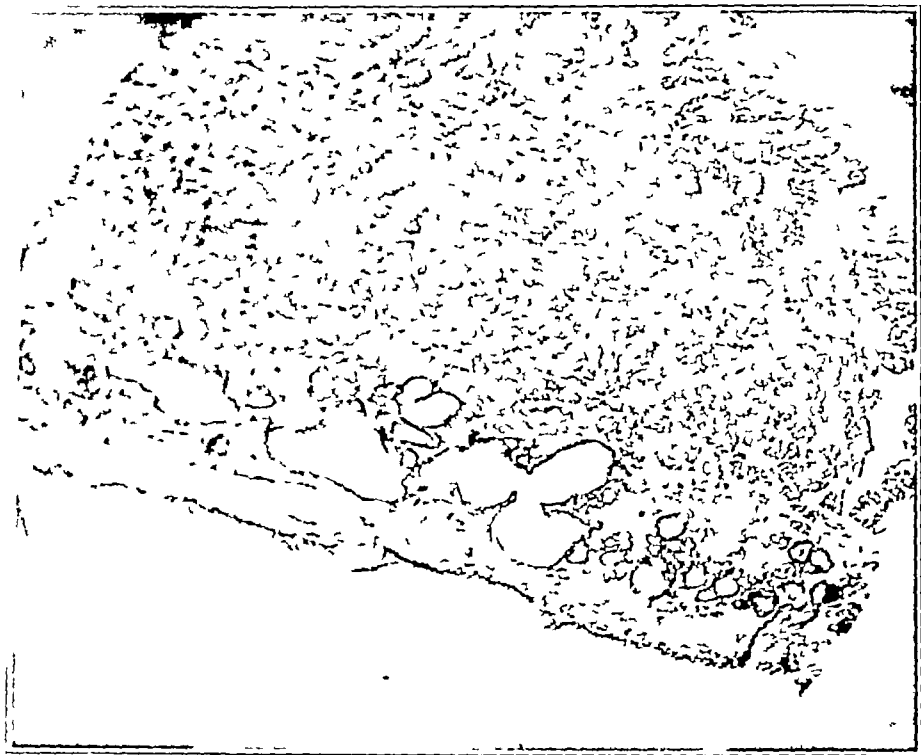


Fig 15—Higher power magnification of figure 14 showing the hyperplastic stroma and absence of microscopic appearance of disintegration (magnification of  $\times 57$ )

a remission following treatment with iodine demonstrated the importance of analyzing all tumors of the thyroid gland in the light of the facts in order to interpret properly their pathologic significance. A pathologic study was then made of 1172 cases of nodular or nodular goiter which were associated with the clinical symptoms of hyperthyroidism and in which the thyroid gland was elevated from 25 to 60 above normal. In 100 cases were of such a degree of severity that the clinical picture of exophthalmic goiter associated with the hyperthyroidism was present in 66 remaining sixty cases the hyperthyroidism was not present.

severity, and a clinical diagnosis of toxic adenoma had been made. The history of these cases was in general that of a nodular goiter associated with hyperthyroidism of long standing.

In nine of the 109 cases (8 per cent), the clinical tumors or nodules resembled true benign parenchymatous neoplasms. These tumors were well defined, not so much by a capsule, but by their microscopic appearance, which was in sharp contrast to the surrounding thyroid parenchyma (fig 14). The great bulk of such a tumor was composed of epithelial tissue supported by a relatively scant stroma. The epithelial

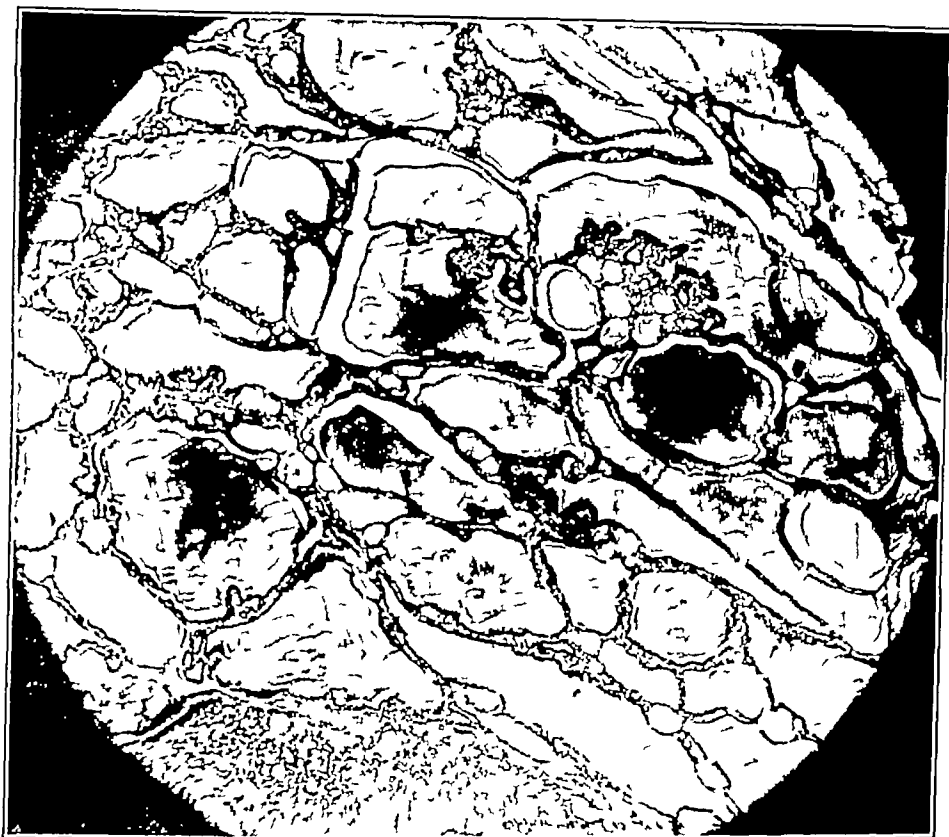


Fig 16—In the lower portion of the photomicrograph a tip of a true benign neoplasm, an adenoma, can be seen. Typical hypertrophy and hyperplasia of thyroid parenchyma surrounding tumor is to be noted. Patient had nodular goiter with exophthalmic syndrome. An artificial iodine remission was established. The thyroid tissue about the neoplasm underwent the average amount of involution, but the histologic appearance of the neoplasm was unaffected. Reduced from a magnification of  $\times 57$ .

cells were, in the main, arranged in narrow anastomosing strands or columns which on examination with the higher power lens proved to be composed of small clusters of epithelium in the form of primitive acini that did not contain a lumen (fig 15). The apexes of the cells abutted on one another, they did not appear to be much increased in size, but were rounder than the cells of the normal adult thyroid parenchyma.

The fourth case observed was that of a child, aged 8, who had extensive pulmonary tuberculosis, operation was not attempted. A fifth case has been seen recently in a thin young woman, aged 18, who was injured in an automobile accident three months prior to examination. A typical deformity was present. There are no symptoms except discomfort on abduction of the arm. She is able to do her work, which is clerical. Her chief complaint is the deformity, and she is still undecided as to whether a scar in this region would be preferable to the present appearance.

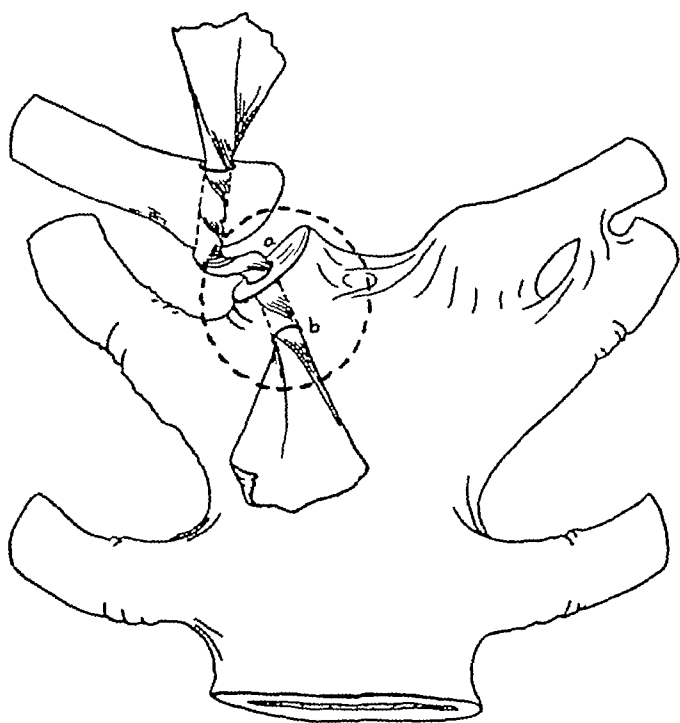


Fig 3—Method of fixing clavicle by drilling the sternal articulation

#### FRACTURE OF THE PATELLA

In this rather common fracture in which operation is the usual procedure, the use of a massive graft of fascia lata seems to be the ideal method of repair. It is desirable to obtain close, accurate and permanent apposition of fragments in such a manner that early motion of the knee joint can be allowed. The end-results by most of the accepted methods of suture are usually good, whether obtained by repair of the capsule and lateral extension tear with chronic catgut or kangaroo tendon or by wiring the fragments together. The capsular suture alone, however, is prone to result in poor approximation of fragments and necessitates several weeks of fixation of the knee joint in extension. refracture or reseparation also has been known to occur.

the joint. The arm was held in extension, and rotation of the forearm was impossible. By gentle traction on the forearm and flexion of the elbow the dislocation was easily reduced.

Operation was advised and accepted. Through a curved incision over the outer aspect of the elbow, the region of the head and neck of the radius and the triangular portion of the upper end of the ulna was exposed. After considerable difficulty, a strip of fascia lata 15 cm wide and 15 cm long was successfully passed around the neck of the radius. This was fenestrated and passed through a 3 mm drill hole in the triangular portion of the ulna, and sutured to itself with several non-absorbable sutures. Gentle motion was started at the end of forty-eight hours. Within four weeks, complete motion had returned, and

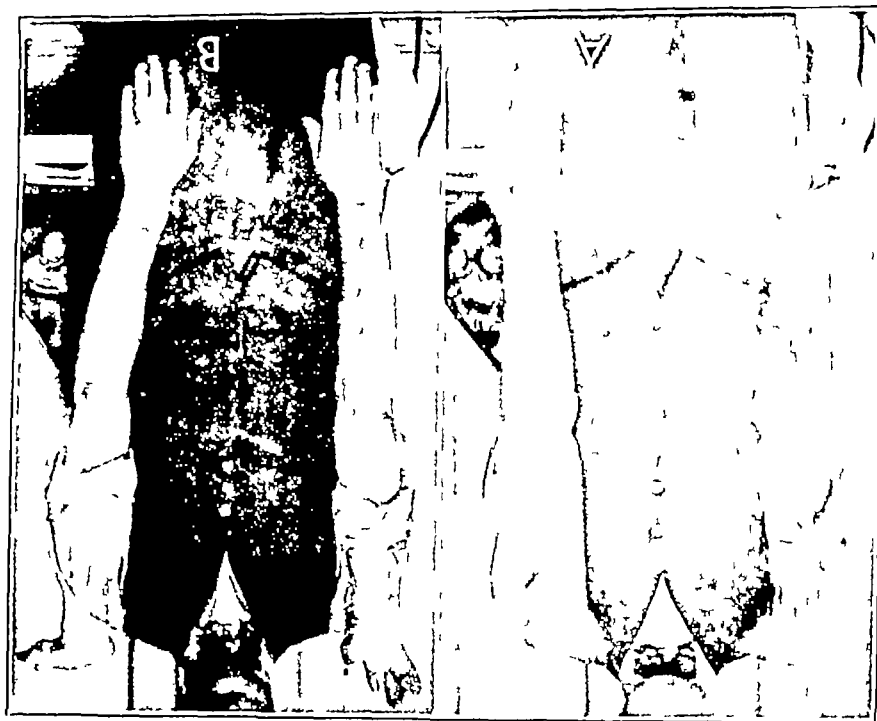


Fig 18—Superimposed exposures of the patient three months after operation for recurrent anterior dislocation of radial head. A, complete range of motion in supination; B, in pronation.

three months after the operation he was allowed to resume his work. The disability had not recurred a year after the operation.

#### SUMMARY

A method of using massive grafts of fresh, autogenous fascia lata in the repair of certain acute lesions of bones and joints is presented. The technique is simple and does not require any unusual apparatus. Fascia lata in the proposed widths and lengths will withstand as much strain on it as any of the foreign body materials in common use for such procedures. It has the distinct advantage of retaining life and forming a permanent structure.

Prolonged disability is common as a result of the long fixation of the knee joint. For this reason many surgeons have returned to fixation by means of silver or bronze wire. The use of the massive fascial graft gives accurate approximation of fragments and allows immediate active motion of the knee joint. Whether or not real bony union takes place is uncertain but the fragments do not separate with use and owing to the safety of early motion of the joint the disability is reduced to a minimum.

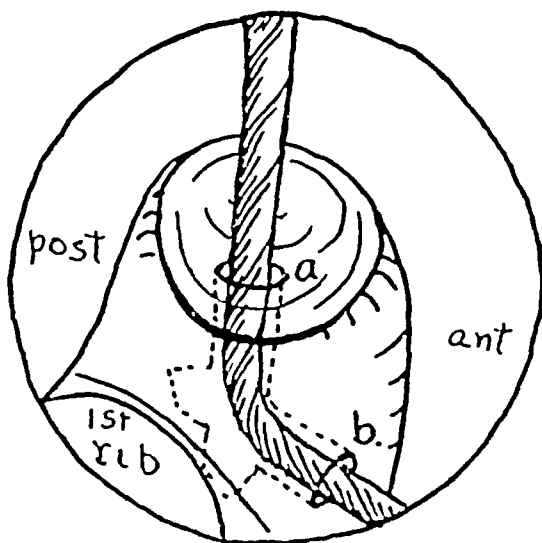
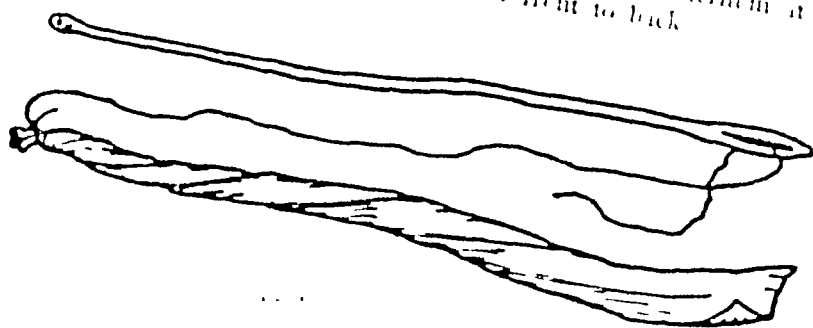


Fig. 4—Lateral view illustrating method of drilling the tunnel at its entrance avoiding danger of complete penetration from front to back.



# CONTRACTION OF THE GALLBLADDER IN THE

COMMON BILIRUBIN (XANTHURUS

NERIOSIS) \*

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ROCKFORD, ILL.

It is now generally accepted by almost all who study the physiology of the gallbladder that it empties through the cystic duct. Furthermore, the contraction that it is emptied by the contraction of an intrinsic musculature is becoming more and more assured. Recent observations on the gallbladder of man (Levine<sup>1</sup>), as well as the observations of Ivy and Oldberg<sup>2</sup> on the effect of secretion on the gallbladder, further substantiate the conclusions of many others that the wall of the vesicle does contract and thereby empties into the cystic and common duct.

As would be expected, most of the recorded observations on the emptying of the gallbladder have been made on common laboratory mammals, such as the dog, cat, rabbit and guinea-pig, because of their accessibility and because of their higher phylogenetic position with an anatomic organization more closely allied to that of man. Relatively few observations have been made on birds, although I have considerable unpublished data on the contraction of the gallbladder in the hen and on the contraction of the common hepatic duct in the pigeon. The reptilians and amphibians remain unexplored as regards this particular process, although I have observed the gallbladders of a few turtles and frogs. Higgins and Mann (1926<sup>3</sup>), in reporting studies of the gallbladders of dogs and guinea-pigs, recorded a few cursory observations on the biliary vesicle in the garter snake (*Lepidosteus*).

Generally, however, the lower vertebrates have contributed but few data to the wealth of information hitherto recorded on the functional activity of the extrahepatic biliary tract. Such a dearth of facts is in a measure lamentable, for in these phylogenetically older and less differentiated species fundamental physiologic processes maintain. It is a fact that with increased specialization and subsequent differentiation accompanying the development of higher forms, some modification

\*From the Division of Experimental Medicine and Pathology, The Mayo Foundation

1 Levine, Samuel. Contraction of the Gallbladder Seen in Man, Arch Int Med 40 420 (Oct) 1927  
2 Ivy, A. C., and Oldberg, Eric. Contraction and Evacuation of Gallbladder Caused by Highly Purified "Secretin" Preparation, Proc. Soc. Exper Biol & Med 25 113, 1927  
3 Higgins, G. M., and Mann, F. C. Observations on the Emptying of the Gallbladder, Am. J. Physiol 78 339 1926

rupted sutures of catgut are inserted. The rent in the lateral extension of the capsule is closed with interrupted no. 2 chromic catgut sutures. It is not necessary to use fascia for these sutures as the tear is through fascial structures which heal readily, once they are approximated, and there can be little, if any, strain on this region, owing to the absolute

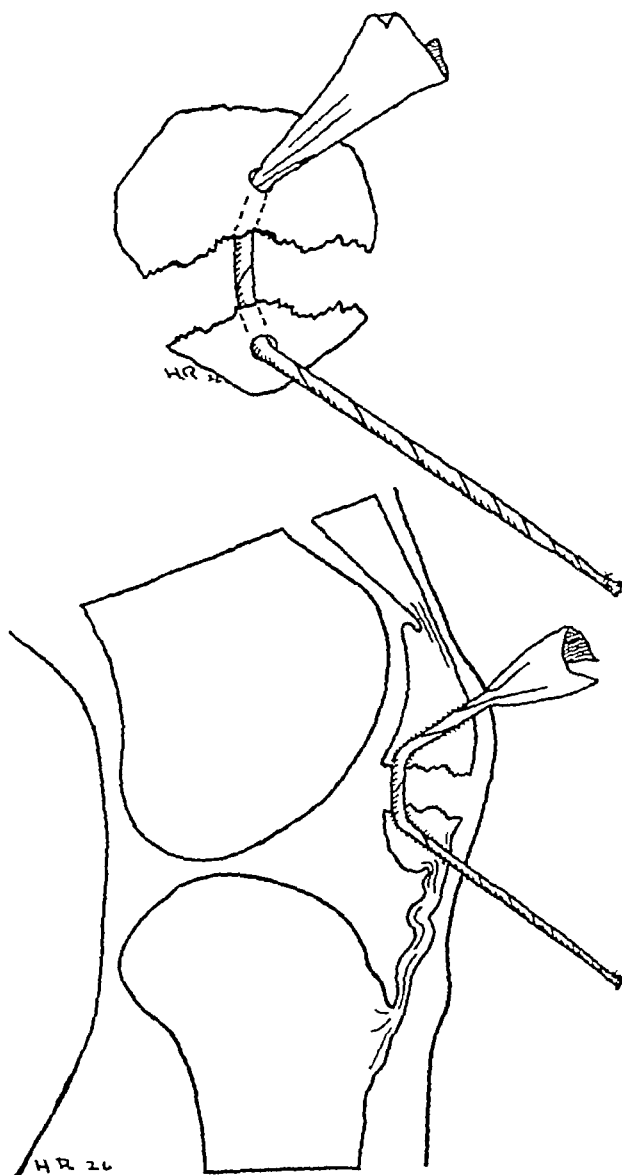


Fig 6—Method used in fracture of the patella. Note the oblique tenestrations in the fragments. The fascia is 3 cm by 24 cm, the drill, 5 mm.

fixation of the fragments of the patella with the fascial graft. Care should be used not to penetrate the joint surface of the patella with the drill. Although in many cases the lower fragment is found badly comminuted, there is usually one principal fragment which can be drilled



of the fundamental body processes may be expected. Nevertheless, a thorough understanding of the fundamental biologic principles that maintain in the lower vertebrates will facilitate the interpretation of the physiologic activities which regularly go on in the mammal.

With the foregoing in mind, a study of the biliary tracts of a large number of fresh-water fishes was undertaken. Through the courtesy of Mr. H. L. Canfield of the United States Bureau of Fisheries at La Crosse, Wis., the entire facilities of the numerous fisheries along the upper Mississippi river were placed at my disposal. With the assistance of the crews employed at the station, a few representative fishes of nearly all the species which inhabit this region were brought to the station laboratory for study. After a preliminary fast the fishes were fed a meal of fat, then, at varying intervals, observations were made on the gallbladder and the extrahepatic biliary tracts. In accordance with existing data on mammalian gallbladders, it was found that in nearly all fishes that were given the meal of fat, the biliary vesicle had emptied within the ensuing two or three hours, and that they were again distended with bile after from four to six hours. In studying as many different species as were available at the station, it appeared that the common bullhead (*Ameiurus nebulosus*), because of the anatomic relations of the gallbladder, liver, common duct and duodenum, would lend itself most suitably to continued observation on the motor activity of the gallbladder and the common bile duct. Again through the courtesy of Mr. Canfield, several cans of these fishes were shipped to Rochester, where they were confined in laboratory tanks equipped with running water, and the following observations were made.

#### ANATOMY OF THE LIVER AND BILIARY TRACT

The liver of the common bullhead is slightly asymmetric and lies in the anterior third of the peritoneal cavity in close contact with the anterior surface to the septum transversum. Although the liver is a single organ, it is composed of two lobes of which the left is somewhat the larger. Each of these two possess smaller anterior, lateral and posterior lobes, thus giving to the margin of the entire organ a somewhat serrate appearance (figs. 1 and 2).

A short esophagus continues posteriorly from the pharynx along the dorsal surface of the liver and between the two main lobes. Slightly posterior to the hilum of the liver, the esophagus continues into a pear-shaped stomach which lies to the left of the median line, posterior and medial to the caudal prolongation of the left lobe of the liver. The stomach continues into the duodenum, which is shaped somewhat like a horseshoe, and makes a wide bend to the right passing through the hilum of the liver, and then posteriorly along the right side of the peritoneum.

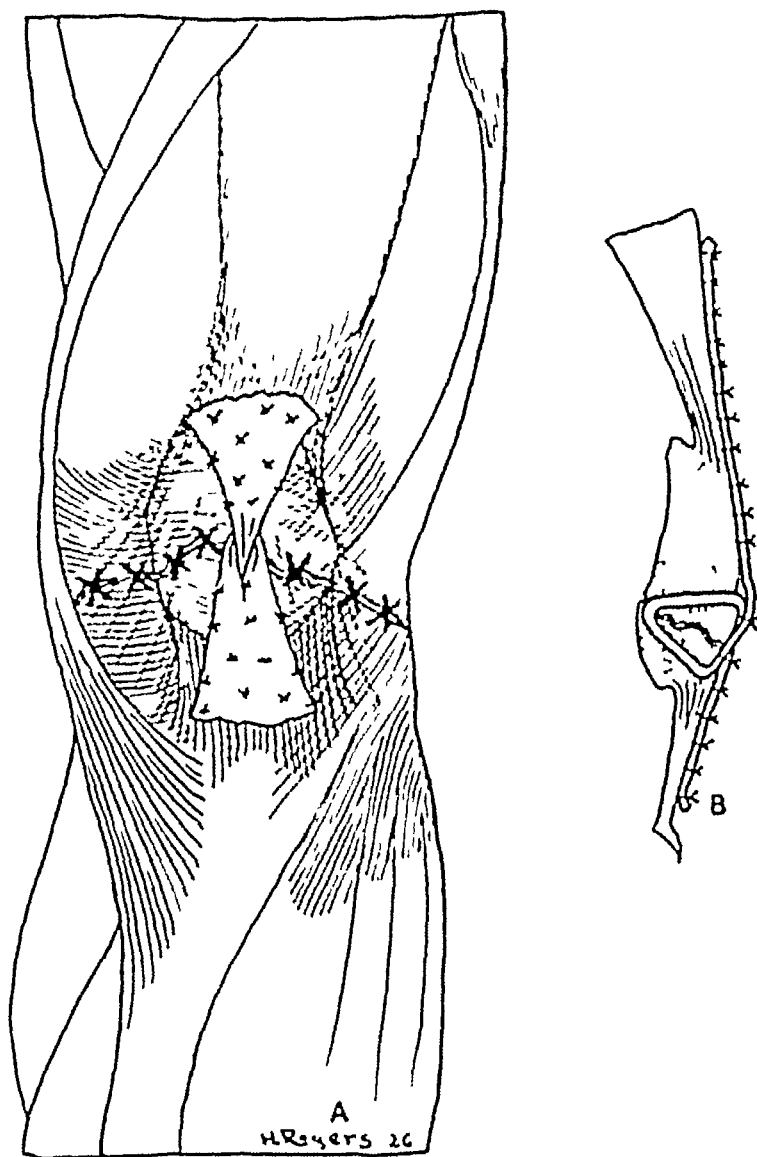


Fig 7—1 illustrates complete fixation of fracture of the patella. The graft can rarely be too long, as the more of it is sutured to the quadriceps above, and to the prepatella tendon below, the stronger the fixation. Note the repair of the lateral extension tear with no. 2 chrome cutgut. B is a lateral diagram of completed fixation. Note the lack of joint penetration.

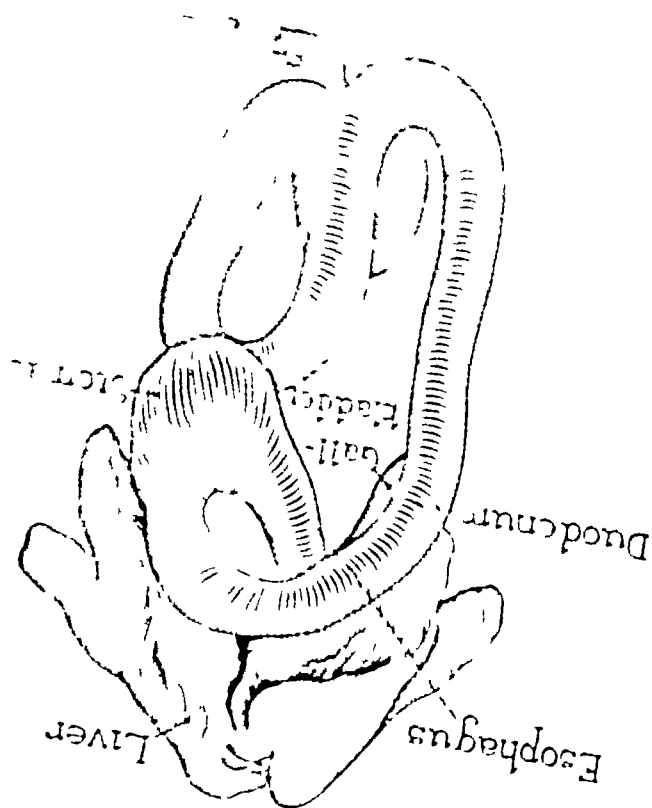


Fig. 1.—The liver, gallbladder and esophagus and rectum are shown in situ. The gallbladder is slightly elevated and the rectum is reflected.



Fig. 2.—CONTRACTION OF GALLBLADDER.

successfully. If such comminution should exist that a fragment of suitable size cannot be found, the graft can be passed beneath the whole of the lower portion and brought out through the patellar tendon immediately below the bone. This has not been found necessary in any case as yet. The graft is taken from the uninjured thigh for several reasons, principally, because the long wound is prone to interfere with early active motion of the knee joint which is begun the day following operation. Also, it is often desirable to have the graft prepared by

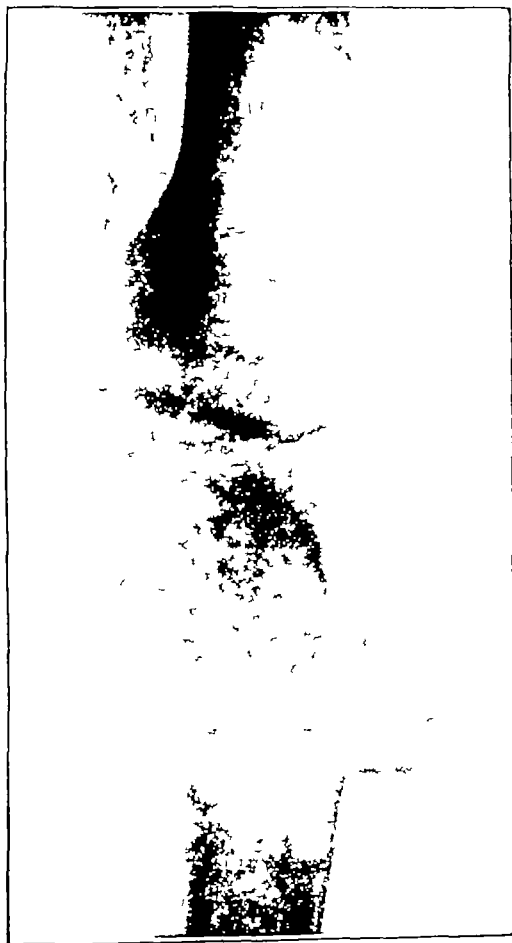


Figure 8



Figure 9

Fig 8—Lateral view of fracture of the patella

Fig 9—Fracture of the patella shown in the preceding figure shortly after fixation by massive fascial graft. Note the excellent approximation of fragments.

an assistant while the patellar fragments are being exposed and drilled. Flexion of the knee beyond 90 degrees should be obtained in less than twelve weeks. Walking should be allowed at the end of four weeks, at first with crutches, weight bearing being gradually allowed to the point of discomfort. After ten weeks, aid should not be needed in walking.

The gallbladder and the extrahepatic biliary tract lie within the portal area, between the liver and the duodenum. The gallbladder lies on the right side of the peritoneal cavity, just dorsal to the descending limb of the duodenum and posterior to the right lobe of the liver, but relatively free from it. It is supported in position by the hepatoduodenal omentum through which several venous channels pass from the intestine by way of the gallbladder to the liver. From six to eight hepatic ducts of varying size empty into an elongated common duct which pursues an arcuate course along the inferior surface of the liver from the neck of the gallbladder to the dorsal surface of the duodenum, 12 mm from the pylorus. A large hepatic duct, occasionally double, which drains the main portion of the right lobe of the liver,

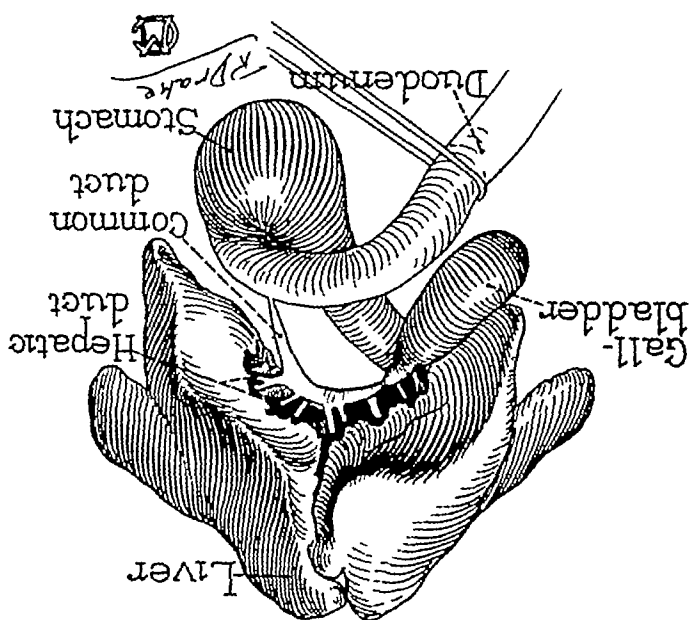


Fig. 3—Partial dissection of the extrahepatic biliary tract in the common bullhead

The remnant appears to empty directly into the neck of the gallbladder. In the upper portion of the common duct, from about 3 to 5 mm distal from the gallbladder, there is a restricted region which usually appears to be in a state of greater tonus than any other portion of the hepatic tract. From this point the dimensions of the common bile duct increase in both directions, and this portion of the hepatic system seems to bear some significant relationship to the physiologic responses that ensue on a fat meal. The common duct from the neck of the gallbladder to the duodenum, when in a state of rest, varies from 18 to 25 mm in length among the different fishes examined. Its greatest diameter, about 2.5 mm, is near the

## FRACTURE OF THE OCCIPITAL

Open reduction of this fracture is becoming more popular following comparative studies of end-results. In cases in which gross separation of fragments has occurred inability to obtain a satisfactory reduction and the long period of fixation in extension necessary to obtain union have brought about more radical measures. The time element of dysfunction has been longer than it should be in many of these cases, and some type of fixation should be used that allows early active



Fig 10—Since in figures 8 and 9 three months after fixation, the patient is now walking. There has not been any tendency for fragments to separate.

motion of the joint. Suture of the torn capsule with ordinary suture material gives good approximation of fragments, but motion must be delayed and reseparation of fragments may occur. Fixation with wire or pegs may allow early motion, but frequently necessitates a second operation for removal of the foreign body. Fixation by means of fascia lata is more nearly ideal than by these other methods. Three patients have been treated in this way so far. Wire had been used previously in the first case, the wire breaking, allowing reseparation at the end of

junction of the left hepatic duct from which point a gradually increasing amount at the duodenum the duct is approximately 0.5 mm in diameter

The venous drainage of the gastro-intestinal tract is usually large for so small an animal (fig 4). The hepatic portal vein carries most of the venous blood from the intestine to the liver but in addition

numerous smaller venous channels continue directly into the horizontal and the descending portions of the duodenum to the liver

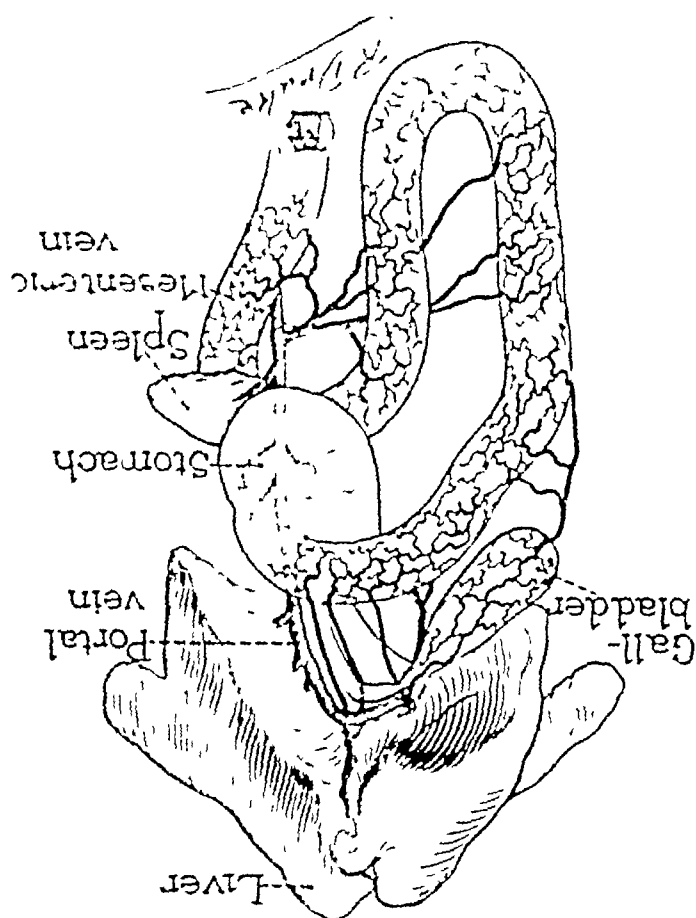




Fig 11—Patient whose roentgenograms are shown in figures 8, 9 and 10, showing amount of active flexion at the end of three months. Note the absence of scar from the thigh on this side. The fascia is taken from the opposite thigh.

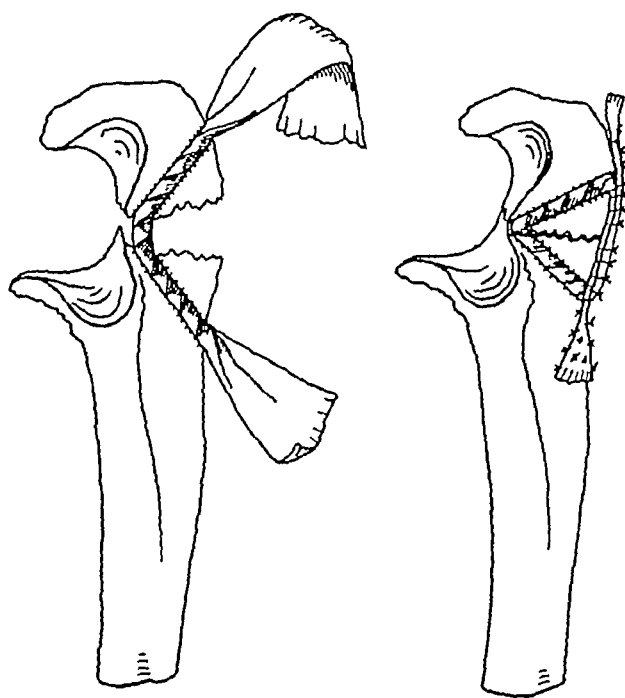


Fig 12—Method of fixation of fracture of the olecranon. Care is taken not to penetrate the joint with the drill. The graft is 2 cm by 20 cm, the drill, 3 mm in diameter. The operation is completed as in figure 7 1 of the patella.



and the dorsal surface of the pylorus. The main channel then continues medially along the inferior surface of the left lobe of the liver and in its course gives off four main veins which enter the substance of the liver while its ultimate distribution is to the inferior surface of the right lobe of the liver where it bifurcates into two main channels which enter the right lobe near the neck of the gallbladder. The veins which drain the ventral wall of the stomach, the duodenum near the pylorus, and the common bile duct, all course independently forward to empty into the portal vein on the inferior surface of the left lobe of the liver. The remaining portion of the duodenum, however, down to within 50 mm of the pylorus, is drained by from three to five independent veins which course obliquely forward into the region of the junction of the gallbladder with the common bile duct and then empty into the portal circulation of this side. The venous distribution is unique in the sense that the radicles carrying the blood from the anterior 50 mm of the duodenum do not have any relation with the hepatic portal system as such, but course independently forward and appear to be definitely associated with the venous drainage of the gallbladder.

With few exceptions, the foregoing description of the anatomic relations of the liver, the gastro-intestinal tract and the related blood supply is most commonly encountered. In this study of seventy-five fishes, however, one fish was opened in which there was complete reversal of the organs of the peritoneal cavity. The lobes of the liver were of the usual proportions, but the larger one was on the right side. Likewise, the pear-shaped stomach was on the right side and the duodenum made the usual broad curve from the pylorus on the right up through the hilum of the liver around to the left side of the peritoneum. The gallbladder was directly below this descending limb of the duodenum, it was slightly larger than the normal vesicle, but was joined to the usual extrahepatic biliary system, all of which was reversed.

#### THE EMPTYING OF THE GALLBLADDER

A phase of this study which is strikingly significant in the light of the present controversy on the emptying of the gallbladder is the contraction activity of the organ in response to a meal of fat. Since the gallbladder is free from the liver and may readily be exposed by simple traction on the duodenum, it is a simple procedure to open the fish, expose the vesicle and observe it for prolonged periods (fig. 5). Early in this study it became evident that the usual physiologic processes would go on only when the viscera so exposed were bathed in a physiologic solution of sodium chloride. Various solutions were tried including Ringer's and Tyrodes, but perhaps the more satisfactory results were attained by 0.6 per cent solution of sodium chloride in tap

ten weeks. The massive graft of fascia lata is used as in the patella. Here again care is taken to pass the drill obliquely so as to prevent penetration of the articular surface (fig. 12). A slightly curved incision is used through the soft parts in order to protect most of the graft from the superficial suture line. Motion is started almost immediately, with gratifying results as regards length of disability and complete restoration of function. A 3 mm. drill is used and a strip of fascia 2 cm. in width and 20 cm. in length is sutured to the triceps tendon and fascia above, and to the fascia of the forearm below with chromic catgut (0) sutures. The torn capsule is sutured with interrupted no. 1 chromic catgut.



Fig. 13—Fracture of the olecranon. The tremendous swelling is due to primary treatment with straight splint applied with adhesive tape. The arm was suspended until the swelling subsided. Fascia lata fixation was performed two weeks after injury.

#### RECURRENT ANTERIOR SUBLUXATION OF THE RADIAL HEAD

A relaxation or a rupture of the orbicular ligament, sufficient to allow the radial head to luxate repeatedly, is an uncommon occurrence in our experience. The one case observed follows.

A thin, healthy, muscular American man, aged 21, while lifting the end of a heavy packing case felt a sudden snapping in his elbow. He was immediately disabled and in great pain with his arm extended, flexion at the elbow and rotation of the forearm being impossible. A physician was called who manipulated the arm without an anesthetic, during which a click was heard followed by

water to still content of the latter being usually high. I was not able to observe the observations to determine means of fertility, certainly, although the bullhead is unusually hardy and is susceptible to loss of fecundity and consequently many fishes were lost during earlier investigations. Numerous methods were tried but the results which was finally resorted to and which has proved satisfactory was the use of 60 per cent sodium chloride in tap water. This solution is oxygenated, passes by gravity through a two-way cock into a collecting tank and into the mouth of the animal. The head tubes are gilled and fishes laid over the viscera and then out of the tank through the second aperture. A constant stream of oxygenated solution passes over



immediate comfort and restoration of motion. A sling was applied and within a few days the man returned to his work. A short time afterward, while producing the same strain, a recurrence of his disability took place. This time the patient and his fellow workmen managed the manipulation successfully, and the man kept at work, favoring his arm as much as possible. After a third recurrence, he applied for treatment.

On examination, the arms were identical in appearance. There was no swelling or discoloration. There was complete motion in all directions and he seemed to be able to hyperextend all his joints. There was no demonstrable tenderness. A roentgenogram failed to show any abnormality. As his disability had always resulted from lifting while his arm was extended, a plaster of paris cast was applied from the wrist to the axilla with elbow held at right angles. With this



Figure 14

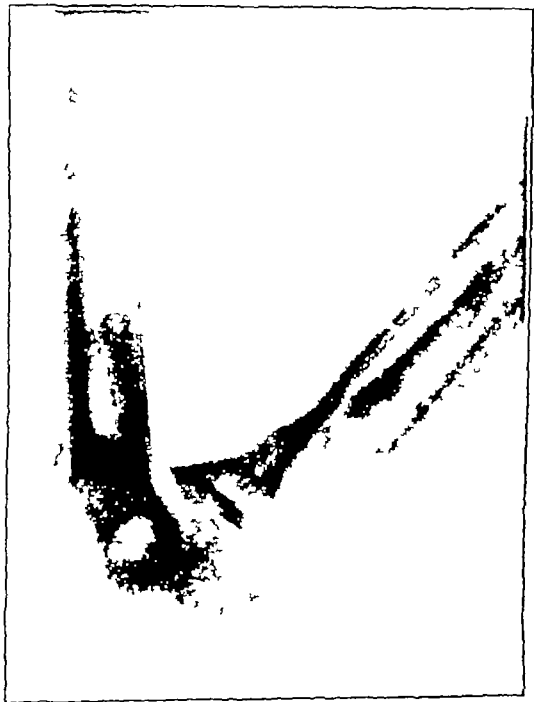


Figure 15

Fig 14—Fracture of the olecranon shown in preceding figure, after fascial fixation

Fig 15—Fracture of the olecranon, shown in two preceding figures, four weeks after fascial fixation, six weeks after injury

the man continued at his work as best he could. The shell was removed at the end of six weeks, and aside from some muscular atrophy, the arm seemed to be normal. In a few days, however, he returned with the story that the condition had recurred during the night, awakening him from sleep. After considerable difficulty, he was able to restore the motion and regain comfort. At this time, ecchymosis or swelling about the elbow was not evident. There was normal motion in all directions. By reproducing the lifting strain, the man was able to demonstrate his lesion. There was a sudden fulness in the anterior cubital space, associated with a depression over the head of the radius on the lateral aspect of

is well distended and the extrahepatic biliary tract is easily recognized into the duodenum, about 1 cm from the pylorus. Immediately, peristalsis of the duodenum is set up. This may have its inception at the point of puncture, or, as often happens, complete contraction of the duodenum occurs at a level 40 mm below the pylorus. From this point a wave continues posteriorly along the intestine, an antiperistaltic wave also usually passes backward to the pylorus. Active peristalsis and antiperistalsis then ensue. Many waves may arise at the pylorus, while others may arise at various distal points and travel in both directions for varying distances. Frequently, too, peristaltic waves are set up in the stomach. These arise in the region of the posterior fundus and the entire stomach is literally crowded up against the pylorus. This is a reflex response on the part of the stomach, for during the peristaltic activity of the duodenum the pyloric sphincter has remained intact, and regurgitation into the stomach has not occurred, for the latter remains pale and flaccid while the duodenum is markedly colored by the injected fat.

During the rather extensive duodenal activity in which peristaltic waves have passed repeatedly over the orifice of the common bile duct, there has been no effect on the gallbladder. The entire extrahepatic biliary tract has remained inactive so far as any muscular movement is concerned, and it may be positively concluded that peristalsis does not have any inciting influence on the discharge of bile from the gallbladder. As the injected fat is gradually forced posteriorly, peristalsis of the duodenum becomes less frequent. After thirty minutes an additional 2 cc of egg-yolk and cream is given in the same way, and again the duodenum becomes active with waves of varying strength and duration. At the end of an hour 2 cc more is given, so that 6 cc of fat constitutes the test meal. As yet there is no indication that the gallbladder will become active, for it hangs just dorsal to the duodenum well distended with bile, its walls somewhat flaccid and without tone. The more or less forceful movements of the duodenum which is in contact with the ventral wall of the vesicle fail to induce movement within the gallbladder. Gradually, however, at intervals after giving the first 2 cc of fat, ranging from an hour and fifteen minutes to an hour and forty-five minutes, an initial tonus is discernible over the entire surface of the gallbladder. There is no movement as yet, but the flaccidity is lost and the wall becomes tense and frequently somewhat lighter. At this time, too, there is slight evidence of contraction in the upper part of the common duct. If the overhanging lobes of the liver are now gently retracted so as to avoid mechanical irritation, marked constriction of the upper common bile duct, about 3 mm

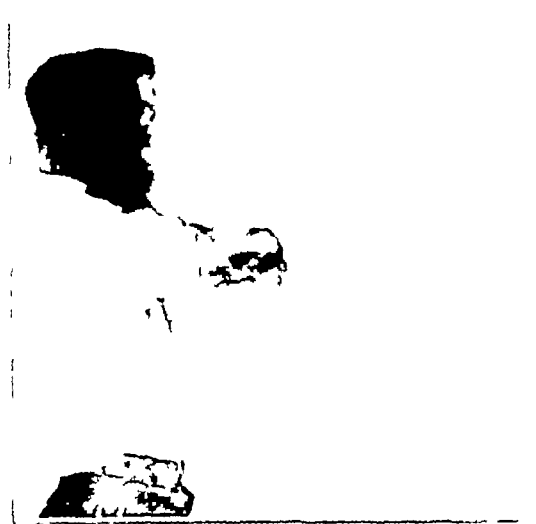


Fig 16—Photograph of patient whose roentgenograms are shown in figures 13, 14 and 15, taken four weeks after fascial suture of the olecranon. The superimposed exposures show the amount of flexion and extension of elbow. The patient was allowed to return to moderately heavy work six weeks after operation.

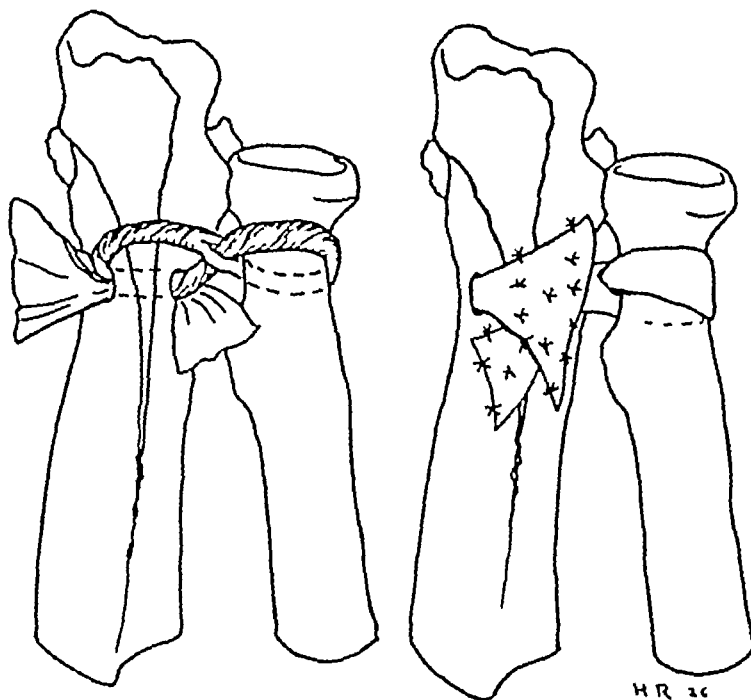


Fig 17—Schematic representation of method used in substituting a fascial graft for the orbicular ligament in the case of recurrent anterior dislocation of the radial head.

from the gallbladder may be recognized. The constriction of this region of the duct together with the onset of tonus over the wall of the gallbladder are the first indications that muscular activity of the biliary tract is likely to follow soon.

Generally within fifteen minutes after the onset of tonus in the gallbladder, contraction waves are visible over the entire vesicle and the common bile duct as well. These waves appear to have their origin at the restricted region of the common bile duct about 3 mm from the neck of the gallbladder. From this point of departure these waves pass over the common duct completely forcing out the bile within the duct into the duodenum. Further coincident with this duct wave, or frequently just after it a wave arising from the same region passes in the reverse direction over the gallbladder, forcing out a quantity of bile into the common bile duct. These waves, then, originate in the common duct and pass over the neck of the gallbladder to involve the fundus as well. Each wave need not be complete in the sense that it involves the entire vesicle, frequently it may fade out after traversing

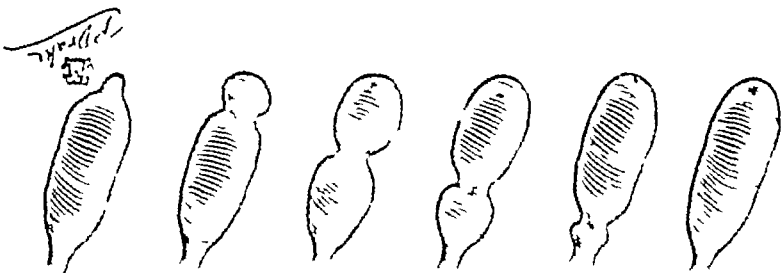


Fig. 6.—A single contraction wave passing over the gallbladder following removal of fat.

over a half or third of the gallbladder. The picture that now presents itself is perhaps more aptly illustrated by that of a toy balloon. If one were to draw this balloon through a small loop which represents the contraction wave, the appearance would be much like that in the gallbladder of the fish during motor activity (fig. 6). All the contraction waves, however, do not travel in the reverse direction. Frequently after the contractile mechanism has been set in motion, by factors as yet undetermined, independent waves of contraction may arise at almost any level on the gallbladder and travel in both directions. They frequently begin at the fundus and travel part way or entirely over the gallbladder, expelling more bile into the common duct. Furthermore these contractions need not always involve the entire diameter of the vesicle at any one level, for occasionally the contractile area may be restricted to only a small portion of the wall, so that peculiar and much distorted figures of an otherwise oval gallbladder are occasionally seen during the motor activity. There does not appear





benign neoplasm The microscopic structure suggested an extreme degree of cellular proliferation and regeneration with the actual formation of new tissue In these tumors, there was not the slightest suggestion of degeneration or histologic regression indicating involution The typical histologic changes denoting hypertrophy and hyperplasia, however, were found in the parenchyma of the thyroid surrounding these tumors and throughout the remainder of the gland (fig 16) In



Fig 18—Another section from same case as in figure 17 Papillomatous infolding of epithelium is more pronounced Typical involutional tumor which has again assumed the appearance of exophthalmic goiter Reduced from a magnification of  $\times 57$

these cases, therefore, it would seem far-fetched, to regard the benign neoplasms as the cause of the hyperthyroidism rather than as coincidental pathologic lesions

In thirty-seven cases (34 per cent), the nodular element was composed of colloid cysts (figs 11, 12 and 13), encapsulated areas of dilated

to be any definite synchronous activity between the motor mechanism of the common duct and that of the gallbladder. Successive contraction waves have been observed to pass over the common duct, unaccompanied by any visible contraction of the gallbladder. Then, too, contraction waves of variable extent may involve all or a part of the gallbladder without any visible motor activity of the common duct. However, in what have been thought to be thoroughly healthy and vigorous animals, both common duct and gallbladder become contractile at about the same time following the ingestion of fats and remain so for a considerable period.

The waves of contraction in both the gallbladder and the common duct do not follow each other in rapid succession. I have often tried to determine the time interval between these successive contractions, but the frequency varies in the same animal and in different animals, dependent no doubt on certain undetermined physiologic factors. Usually such contractions follow each other at from two-minute to four-minute intervals. Although the waves are not frequent, when they once appear they traverse either the common duct or the gallbladder at a rate as rapid as the normal peristalsis of the duodenum. Throughout this period of motor activity of the common bile duct and the gallbladder, the duodenum, except for occasional peristaltic movements, has been inactive. Thus the movement of the biliary tract is independent of the activity of the duodenum, and the gallbladder empties without the so-called sucking of the contracting duodenum.

The gallbladder may empty itself completely, it has often been noted on opening an animal that it was entirely void of bile appearing contracted to not more than 2 or 3 mm in diameter and to 8 or 10 mm in length. This degree of emptying was never experienced in animals under observation. Although small amounts of bile were ejected with each contraction wave, the gallbladder usually failed to contract to less than one third of its original size. Gradually the waves become more infrequent and finally cease entirely, although considerable bile may still remain within the gallbladder. The accountable factors in the cessation of the flow of bile are unknown. Fatigue or confinement may be a factor, and yet when the fish is taken from the tank it is still vigorous and given to the usual habits of jumping and splashing. These fishes do not withstand laboratory confinement in the same way or so satisfactorily as do those of the ganoid group. I have retained garpike in laboratory tanks for long periods, but the bullhead gradually loses vigor and becomes inactive even though aerated water and food are provided. This marked lassitude is reflected in the physiologic response of the biliary mechanism to the usual meal of fat. Fishes that have been retained in laboratory tanks for two weeks are less likely to show marked motor activity of the biliary tract following

Cotton<sup>5</sup> recently reported five cases of pyogenic joints, in three of which there were infections with *Staphylococcus aureus*. He irrigated these with 1 to 15,000 mercuric chloride in salt solution, and the joints became normal. He said that so long as infection was confined to the synovial cavity, the joint was sterilizable. The question arises as to whether the mechanical cleansing is not the main factor in this treatment. In 1925, Gatch, Trusler and Owen,<sup>6</sup> experimenting with intravenous injections into rabbits, showed that of a number of preparations of gentian violet the least toxic was physiologic sodium chloride solution. It was also shown that gentian violet in isotonic 4 per cent dextrose possessed less toxicity than gentian violet in distilled water. Gentian violet had a solubility of 39 per cent in physiologic sodium chloride solution compared to 94 per cent in distilled water. They concluded that gentian violet would exert a temporary bacteriostatic action in septicemia, but that the ultimate benefits depended on the resistive powers of the patient.

In 1925, Brill and Myers<sup>7</sup> showed that a blood medium made up with gentian violet to a dilution of 1 to 10,000 would kill the growth of a *Staphylococcus albus* organism only after twenty-four hours' contact. In reviewing the literature on experimental arthritis, no reference can be found to joints infected with staphylococcus. All the experimentation has been with strains of streptococcus, mostly of the viridans type. A most interesting and instructive piece of work was done by Jackson<sup>8</sup> in 1913. Rabbits were given intravenous injections of a culture of streptococcus, and studies were made of the joints in from two hours to four months after infection. It was shown that after two hours the streptococcus could be demonstrated in the vessels of the perarticular tissues. In ten hours intravascular collections of leukocytes were present. In twenty-four hours there was an exudation and migration of the leukocytes into the joint cavity. Thus, there was an incubation period of twenty-four hours between the time of the intravenous injection of the streptococcus and the time the joint becomes infected. The changes were only those consistent with the varying phases of a single inflammatory process. The changes depended on the independent localization of the bacteria in the joint cavity, in the tissues

5 Cotton, F. J. J Bone & Joint Surg 8 395, 1926

6 Gatch, W. D., Trusler, H. M., and Owen, J. E. Treatment of General

Septicemia by Gentian Violet and Mercurochrome-220 Soluble, J A M A 85

894 (Sept 19) 1925

7 Brill, I. C., and Myers, H. B. Mercurochrome-220 Soluble and Gentian

Violet, Bactericidal Efficiency by Intravenous Route J A M A 84 879

(March 21) 1925

8 Jackson, Leila J Infect Dis 12 364, 1913

a meal of fat than those observed immediately on their arrival at the laboratory. In certain fishes thus confined, I have failed to observe any response to the fat, while in others, contraction waves of the common duct were faintly visible, but only after a prolonged interval following the administration of the meal. Obviously, then, to secure the best results, only healthy, vigorous fishes should be used, and these soon after they reach the laboratory.

#### HISTOLOGY OF THE INTRAHEPATIC BILIARY TRACT

The gallbladder is an extremely delicate organ, but, nevertheless, following proper stimulation, it possesses sufficient contractile tissue to eject bile. In the extended condition, the wall in the region of the fundus is slightly more than one fiftieth of a millimeter thick. The mucosa, which comprises a little less than one half of the entire thickness of the wall, is composed of characteristic columnar epithelium of tall narrow cells with nuclei in the base. Differential staining shows that the remainder of the wall is a composite structure of connective tissue and muscle fibers interspersed with abundant vascular channels. There appears to be considerable interlacing of the two tissues, but most of the muscle fibers are grouped into a compact layer coursing in the circular direction and supported on the sides by connective tissue fibrils. In the neck of the gallbladder, the muscle fibers are more loosely arranged, and here it is easy to identify a narrow band of longitudinal muscle fibers and diagonal fibers, as well as those running around the vesicle. The longitudinal fibers are interspersed with connective tissue fibers.

There is gradual reduction in the proportions of the tract passing from the gallbladder to the common bile duct, but the tissues of one continue imperceptibly into those of the other. Within the upper portion of the duct a conspicuous band of muscle fibers, both circular and longitudinal, lies just external to an equally prominent layer of connective tissue, which is separated from high columnar epithelium by a thin basement membrane.

Grossly, the hepatic ducts which drain the right lobe of the liver appear to empty into the neck of the gallbladder. This is not actually true, for they penetrate only the serosal and muscular tunics of the vesicle and then continue posteriorly within the connective tissue of the duct just external to the mucosa (fig. 7). In some cases these hepatic ducts extend for 2 mm. or more within the intramural portion of the cystic duct before emptying into its lumen. In this connection, it may be noted that the tissue of the hepatic ducts resembles the rest of the biliary tract, with especially prominent circular and longitudinal bands of muscle. When the wall of the cystic duct is penetrated, however, it is found that all muscle tissue of the hepatic duct discon-

surrounding the blood vessels of the synovial membrane, in the plicae synoviales, in the tendon sheaths and in the blood vessels of the periosteum and bone marrow near the epiphyseal cartilage. The involvement of the perisynovial and parasyovial structures was marked, and some nodular formation was found in the tissues about the joint.

In 1915, Faber<sup>9</sup> showed that by a process of first injecting small quantities of a culture of *Staphylococcus aureus* into the joint, and of following this with one intravenous injection, arthritis could be caused constantly. Without previous sensitization of the joint, two or three intravenous injections were required to cause the arthritis.

In 1914, Rothschild and Thalhimer<sup>10</sup> showed that after intravenous injections of a *Staphylococcus mitis*, arthritis was caused in 50 per cent of the rabbits experimentally with and that the organism could be recovered from one third of the affected joints.

#### METHOD OF EXPERIMENTS

First, the knee joint of the rabbit was directly infected by an instillation of 0.1 cc of a twenty-four hour broth culture of a pure strain of *Staphylococcus aureus*. Second, when a definite local reaction was present in the knee, manifested by increase in local heat, swelling and limitation of motion, the joint was aspirated for culture and gentian violet was injected. The clinical manifestations in the joint were followed until the active process had subsided. During this period roentgenograms were taken. Frequent aspirations of the joint for culture were made. The animal was then killed, and the joint studied grossly and microscopically. From one to three injections of gentian violet of 1 cc each were made following the infection. The gentian violet was used in strengths of 1 to 400 (0.25 per cent) and 1 to 200 (0.5 per cent). It was prepared in three different mediums, namely, distilled water, 4 per cent dextrose and olive oil.

Thirty rabbits were used in the problem. Attempts were made to sterilize the infected knee joints of 20 of these. This was successful in seventeen, or 85 per cent of the cases. Four rabbits were used as *Staphylococcus aureus* controls, and three as gentian violet controls. Three rabbits died of intercurrent causes soon after the onset of the infection, one from an infection of the blood stream one from a severe diarrhoea following the instillation of the gentian and one from an unknown cause.

The report of the experimental work is divided into four parts, namely bacteriologic, clinical, roentgenologic and pathologic.

<sup>9</sup> Faber, H. K. J. Exper. Med. 22: 615, 1915.

<sup>10</sup> Rothschild and Thalhimer. J. Exper. Med. 19: 444, 1914.

tinues, so that within the intramural portion of the upper part of the common bile duct, the hepatic ducts consist of columnar epithelium only, supported by a wide band of connective tissue. There are numerous small hepatic ducts, and as many as four of these have been observed to enter the wall of the major duct and course independently into its lumen (fig 7)



Fig 7—Partial cross-section of the neck of the gallbladder shows four hepatic ducts coursing within the connective tissue, between the mucosa and muscular tunics,  $\times 220$

The anterior group of hepatic ducts which drain the right lobe of the liver empty into the lumen of the common duct within the region which is essentially active after the meal of fat. A constricted region of the upper part of the hepatic tract has been described from which as a center, contraction waves pass over the common duct and distally over the gallbladder. Sections of the tract at this point do not reveal

## BACTERIOLOGIC STUDY

A study was made of twenty-four infected joints. Seventeen were successfully sterilized, three were unsuccessfully sterilized and four were controls.

1 *Successfully Sterilized*—These joints required from one to fifty-three days for the sterilization. The time depended on the frequency of administration, the strength and the medium of the gentian violet. They are divided into four groups, according to the gentian violet preparation used.

(a) 0.25 Per Cent Aqueous Gentian. Four rabbits were given from two to three injections in from one to twenty-one days after infection. The joints were sterile in from nineteen to fifty-three days, the average being twenty-one days. Two rabbits which did not show bacteriologic evidence of infection, but did show clinical evidence, were given one injection each. These showed a complete subsidence of the acute condition of the joints in a few days' time.

(b) 0.25 Per Cent Dextrose Gentian. Three rabbits were given from one to two injections in from one to three days after infection. The joints were sterile in from four to twenty-eight days, the average being thirteen days.

(c) 0.5 Per Cent Dextrose Gentian. Four rabbits were given from two to three injections in from one to three days after infection. The joints were sterile in from two to four days, the average being three days.

(d) 0.5 Per Cent Olive Oil Gentian. Four rabbits were given three injections in from one to four days after infection. The joints were sterile in from fifteen to twenty-nine days, the average being twenty-two days.

2 *Unsuccessfully Sterilized*—One animal received two injections of 0.25 per cent aqueous gentian in two and four days after infection. Two received two injections each of 0.25 per cent dextrose gentian in from one to five days after infection. One of the latter two showed a negative culture at the end of ten days, but later on the twenty-eighth and thirty-second day positive cultures were obtained.

3 *Control *Staphylococcus aureus**—The four rabbits in this group showed positive cultures. One of these, however, had a negative culture on the twenty-eighth day, but later on the forty-second day at autopsy the culture was positive.

## CLINICAL STUDY

The most important clinical evidence of infection noted were the limitation of motion, the swelling and the increase in local heat. The first two signs were the most exact and had the most relative value in the making of a comparison of the amount of clinical activity in the joints. The limitation of motion is reported in degrees of limitation of extension, for instance, a joint capable of extension only to a right angle is reported as 90 degree limitation of extension. The limitation of motion is placed in the following four groups: (1) between 0 and 10 degrees, (2) between 10 and 60 degrees, (3) between 60 and 90 degrees, and (4) between 90 and 135 degrees. The amount of swelling is reported as slight, fair, moderate or large. The last examination of the knee in the living animal is used in the analysis, as shown

essential differences from the region immediately above or below, but a study of the distribution of nerves to this area, now in progress, may be instructive. The layer of muscle is more compact, however, and circular and longitudinal fibrils intermingle freely with a preponderance of the circular external to the longitudinal, but the layer of connective tissue immediately beneath the muscle is more loosely bound and more

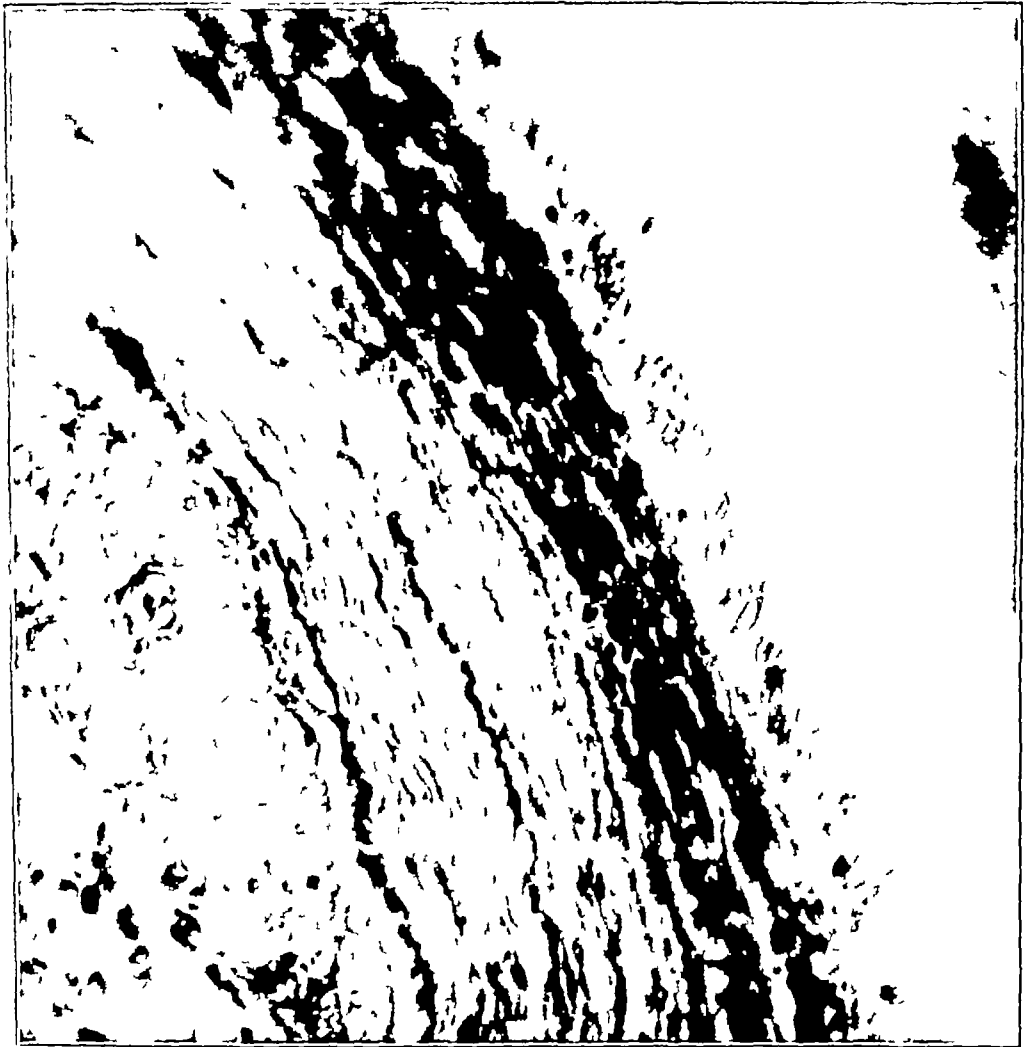


Fig 8—Partial cross-section of the wall of the common bile duct shows the wide band of muscle fibers external to the connective tissue layer,  $\times 570$

hyperemic than elsewhere. The cells of the mucosa are more compressed than in other parts, a condition probably induced by the tonus of the muscle tunic at the time of fixation.

From this constricted portion of the hepatic tract, which perhaps could well be said to be the site of confluence of the neck of the gallbladder with the common duct, there is a gradual increase in the



in table 1. All the joints of the successfully sterilized, the unsuccessful-fully sterilized and the control groups are listed according to the amount of motion and swelling, with an average of each group. In figure 1, there is a comparison of the amount of motion in each group over a period of thirty days. In figure 2, there is a comparison of the amount of motion in each of the four gentian groups of the sterilized joints over a period of thirty days.

ROENTGENOLOGIC STUDY

In taking the roentgenograms attempts were made to follow the clinical changes of the joints in the different stages of activity. From

TABLE 1—Degree of Clinical Activity in Hip Joints Manifested by Limitation of Motion and Swelling

Limit of motion	0	1-10°	10-40°	40-60°	60-90°	90-135°	Various	Total joints
Swelling		Slight	Fair	Moderate	Moderate	Severe		
1 Successfully sterilized	1	1	1	2	1	1	87	6
(a) 0.2% aqueous gentian								
(1) Limit of motion								
(2) Swelling								
(b) 0.25% dextrose gentian								
(1) Limit of motion	1	1	1	2	1	1	85°	3
(2) Swelling								
(c) 0.5% dextrose gentian	1							1
(1) Limit of motion								
(2) Swelling								
(d) 0.5% olive oil gentian								
(1) Limit of motion								
(2) Swelling								
2 Unsuccessfully sterilized								3
(1) Limit of motion								
(2) Swelling								
3 Control								
(a) Staphylococcus aureus								
(1) Limit of motion								
(2) Swelling								
(b) Gentian violet	1							3
(1) Limit of motion								
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diameter of the channel toward the duodenum. This increase reaches maximal proportions at the site of confluence with the hepatic ducts of the left lobe of the liver, from which point there is a gradual reduction in the circular dimensions of the common duct until it reaches the duodenum. This increase is largely due to an abundance of muscle fibers, both longitudinal and circular, which extend throughout the entire length of the common duct. In the upper portion of the common duct, the muscle and the layers of connective tissue are of equal width.



Fig 9—A cross-section of the intraduodenal portion of the common bile duct, wide band of muscle fibers and narrow zone of connective tissue may be noted,  $\times 127$

while nearer the duodenum there is a progressive increase in the amount of muscle tissue and a decrease in the extent of the layer of connective tissue. In the lower part of the common duct, the layer of muscle is twice as thick as that of the connective tissue. Circular muscle fibers are more abundant but external to these, and in more or less restricted areas, there are scattered muscle bundles running longitudinally and diagonally (fig 8). Continuing intraduodenally, the

2 *Unsuccessfully Sterilized*—All these animals showed a large amount of bone destruction on the joint surfaces, and changes in the tibia and femur proper changes as in the unsuccessfully sterilized group

3 *Controls*—(a) *Staphylococcus aureus* All showed essentially the same changes as in the unsuccessfully sterilized group

(b) Gentian Violet No changes were noted in the joint surfaces or spaces

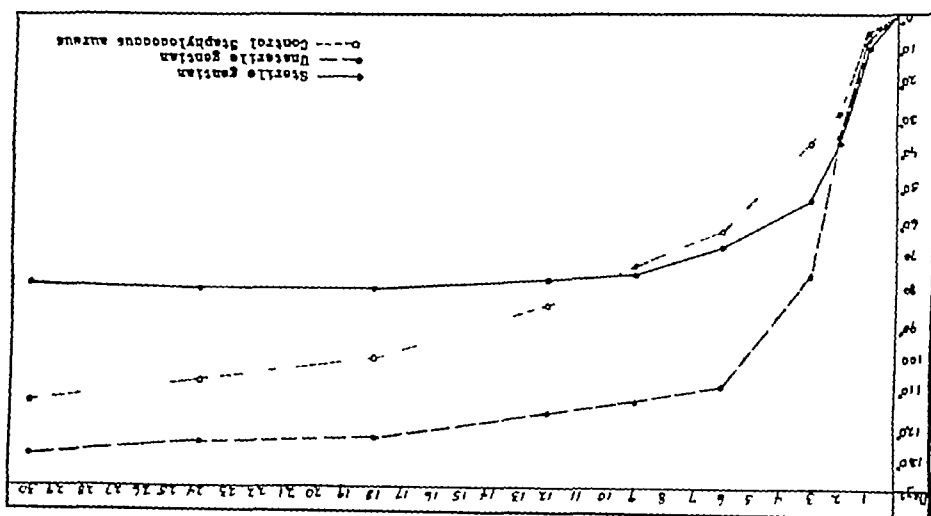


Fig 1—Clinical reaction in degrees of limitation of extension of the successfully sterilized, the unsuccessfully sterilized and the control joints infected with *Staphylococcus aureus* over a period of thirty days

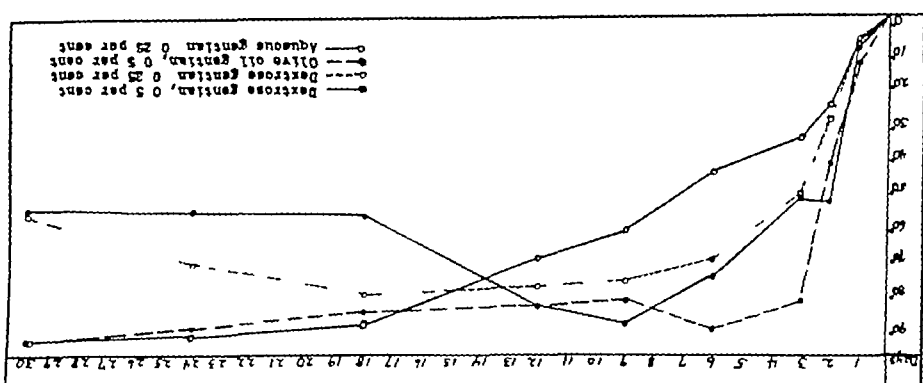


Fig 2—Clinical reaction in degrees of limitation of extension of the successfully sterilized joints in the group in which 0.5 per cent devtrose, 0.25 per cent devtrose, 0.5 per cent olive oil and 0.25 per cent aqueous gentian were used over a period of thirty days. The reaction was markedly less in the groups in which devtrose and gentian were used

#### GROSS PATHOLOGIC STUDY

Eighteen of the twenty-seven joints were examined and the appearance of the joint structures was noted

1 *Successfully Sterilized*—(a) and (b) 0.25 Per Cent Aqueous and Devtrose Gentian Seven of the nine joints in these groups were opened. Four showed a marked bone destruction of the surfaces of the femur, tibia and patella. Three

preponderance of muscle tissue is even greater, and the connective tissue is restricted to a narrow zone immediately around the mucosa.

The bullhead differs from many higher vertebrates in that the common duct passes directly through the duodenal wall into the lumen of the intestine, opening by a single orifice. The muscle of the common duct continues throughout the entire intramural course and there is an appreciable increase in the volume of this tissue within the duodenal wall. Whether this should be designated a sphincter of Oddi is questioned, it is but a continuation of the extensive musculature of the extraduodenal common duct and is not abruptly increased on entering the wall of the intestinal tract. A layer of muscle, however, entirely independent of the muscularis of the duodenum and approximately equal to it in thickness, surrounds the intramural portion of the common duct and is probably highly contractile during the evacuation of the biliary tract such as occurs following the meal of fat (fig. 9).

#### COMMENT

These observations on the contraction of the extrahepatic biliary tract in the common bullhead following a meal rich in fats are interesting because of the facts disclosed pertinent to the manner in which the bile in the gallbladder is discharged. In studies hitherto reported various conflicting interpretations of the mechanism of emptying the gallbladder have been advanced. Observations have been made on mammals, particularly on the cat and the dog, and anesthesia or extensive preliminary surgical procedures may have complicated the ensuing normal physiologic processes. These particular factors are probably obviated in the selection of the fish as a fit subject for such observations. It is not likely that the careful confinement of such an animal for any given length of time will essentially modify the physiologic responses of the body, nor is it likely that psychologic function would be so disturbed as seriously to impair the normal nervous activity accompanying the gastro-intestinal response to diet. Thus it would seem that in the fish one may observe the processes that obtain in a normal biliary tract uninterrupted or unmodified by the nervous reactions set up in more highly organized animals under essentially experimental conditions.

Obviously caution must be used in applying conclusions of observations made on a fish to the highly organized animal. It is probably true that in the modification of structure pursuant to specialization, differentiation in the physiologic response may have arisen, and yet with the present status and limitations of study one cannot be at all certain that contractile processes so clearly shown in the biliary tract of fishes may not be true for higher animals as well. The anatomic organization of the tracts in the various animals studied is essentially the same.

showed a severe fibrous tissue reaction in the joint proper. In six, nodules of cheesy, caseous material were seen about the joints. Pus was found in the joints of three, gentian in the joints of two and gentian in the surrounding tissues of five.

(c) 0.5 Per Cent Dextrose Gentian. Two of the four in this group were examined. One showed a rather large amount of gentian in the joint proper and in the surrounding tissues, without changes in the joint or pus. This was

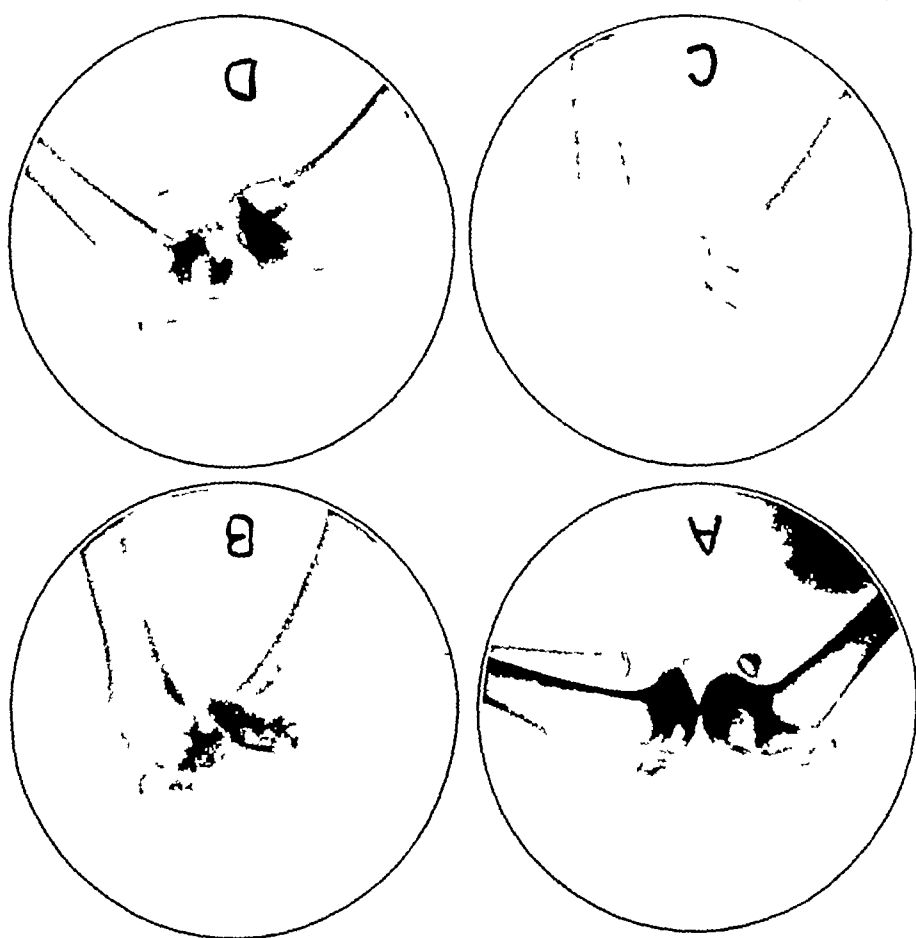


Fig. 3—Early roentgen-ray changes in a successfully sterilized, an unsuccessfully sterilized and a control joint infected with *Staphylococcus aureus*. A indicates a normal joint, B, sterile joint of rabbit 28 on ninth day—0.5 per cent dextrose gentian injected, C, unsterile joint of rabbit 23 on eighth day—0.25 per cent dextrose gentian injected, D, control joint of rabbit 1 infected with *Staphylococcus aureus* on tenth day. The following points should be noted: (1) the clouding of joints B, C and D, compared with the normal joint A, and (2) the irregularity along the under surface of the patella, the anterior border of the femur and the posterior portion of the tibia in the control joint D, which is not seen in B and C.

on the twenty-first day after infection. The other joint was opened five and one-half months after infection. It presented an entirely different picture. There was a marked erosion of all cartilage with bits of cartilage in the joint. The

All observers agree that the biliary tracts of fishes and other animals are composed of serosa, muscle tunic of varying proportions connective tissue sheath and mucosa of columnar epithelium. Differences may abound in the relative abundance of the various tissues involved or in peculiar modifications of certain of the tissues to form additional structures such as the valves of Heister, gland of Lushka or parietal sacculi, but the essential groundwork in the structural organization of these extrahepatic biliary tracts is identical. There is some basis for assuming, then, that there may be unity in the physiologic responses of these biliary tracts although phylogenetically so remote.

It is not my purpose here to attempt a correlation of fishes and other animals, or to attempt any explanation of the phenomena known to occur in the biliary tracts of mammals with facts observed in the fish. But rather, I wish further to substantiate certain conclusions hitherto reached from studies on the dog and the guinea-pig and to show that the lowly fish possesses an hepatic organization which responds to fat in a manner compatible with previously recorded data on the emptying of the gallbladder.

Gathered from the available sources of published data on the emptying of the gallbladder, various factors have been accorded some influence on the discharge of bile from the gallbladder. Chief among these are intra-abdominal pressure, secretory pressure of the liver, peristalsis of the duodenum together with duodenal tone and contraction of the muscle layer within the wall of the gallbladder. Certain of these factors have been stressed to the entire elimination of the others, but perhaps more recently the preponderance of data favors contraction.

In the light of recent observations, adequate data are presented to throw considerable doubt on the validity of certain of the foregoing factors. First, the animal under experiment is opened by a median abdominal incision so that a major portion of the viscera including the bile tract is exposed during the entire period. Extiraneous pressure of any sort is thereby obviated, and the evidence points conclusively to the fact that intra-abdominal pressure or any other form of "squeeze" is not a factor in the discharge of bile from the gallbladder.

During the earlier part of the experiment, soon after the introduction of the fat in the duodenum, hepatic bile passes through the bile duct into the duodenum. This continues to flow for some time, and yet there is not the slightest evidence that the bile in the gallbladder is discharged into the common duct at any time during these early stages of the experiment.

When the abdominal cavity is opened, the entire gastro-intestinal tract is in a state of rest. The tract, being devoid of food for some time, is empty and the walls are collapsed. Immediately on the injection of 2 cc. of egg-yolk and cream into the duodenum, the tract comes

crucial ligaments were relaxed, and they allowed an abnormal amount of lateral mobility. A slight fibrous tissue proliferation was present on the sides of the joint.

(d) 0.5 Per Cent Olive Oil Gentian. Two of the four joints in this group were opened. These showed pus in the joint, and pus and gentian in the surrounding tissues. There was a roughening of the articular cartilage in both, with a thinning of the crucial ligaments and semilunar cartilages in one. The lower end of the femur in one showed a nodular swelling.

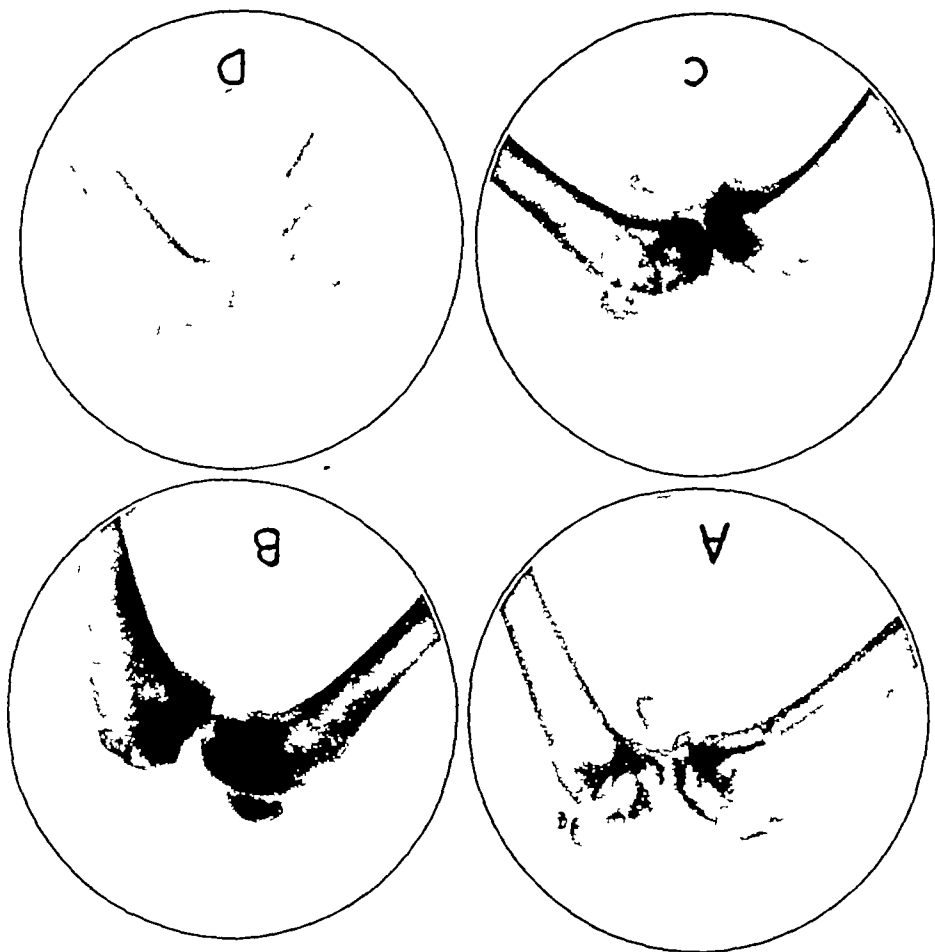


Fig 4—Later roentgen-ray changes in two successfully sterilized joints and one unsuccessfully sterilized joint, compared with a control joint in which gentian was used. A indicates a control joint, injected with gentian, from rabbit 15 on the thirty-second day—0.25 per cent dextrose injected, B, sterile joint from rabbit 26 on twenty-seventh day—0.5 per cent olive oil gentian injected, C, sterile joint of rabbit 21 on thirty-second day—0.25 per cent dextrose injected, D, unsterile joint of rabbit 14 on thirty-second day—0.25 per cent dextrose gentian injected. The following points should be noted: (1) the complete absence of changes in the control joint A, in which gentian was used, (2) the marked irregularity and bone destruction in B, C and D, and (3) the areas of absorption in D.

2 *Unsuccessfully Sterilized*—One of the three in this group was opened. This showed pus in the joint and tissues, gentian in the tissues, a marked fibrous tissue proliferation in the joint and a roughening of all bony surfaces.

into tone, the muscles contract and peristalsis becomes active. Anti-peristalsis of the duodenal region is especially characteristic. The stomach, although without the food as a stimulating factor, becomes contractile. These peristaltic waves of varying lengths and force which pass repeatedly over the orifice of the common bile duct do not appear to have any effect on the flow of bile. The gallbladder remains entirely inactive throughout the entire period that the duodenum is motile. The common duct, too, is inactive so far as movement is concerned during this interval. The conclusion is obvious then, that peristalsis or muscle tone of the duodenum does not have any effect on the discharge of bile in this animal.

This entire study adequately supports the observation, now generally accepted, that bile is discharged from the gallbladder by the active contraction of an intrinsic musculature. The common duct is also shown to be contractile, aiding thereby the evacuation of the gallbladder. Extrahepatic biliary motility is not apparent until from an hour to an hour and a half after the injection of fat into the duodenum. This motility expresses itself in the form of contraction waves that arise in the upper part of the hepatic tract and travel toward the duodenum in one direction and back over the gallbladder in the other direction. These waves are not interrelated, for one may arise without the other. Usually a wave that arises at the customary site, to course toward the duodenum will pass throughout the common duct, while waves passing over the gallbladder are frequently incomplete. While the gallbladder is in a state of contraction, waves may arise at the fundus and pass partially or completely over it, as well as in the reverse direction.

The time interval before the contraction of the gallbladder following the introduction of the fat suggests that the causal factors involved in this motility are in some way related to absorption. The independent vascular connection of the duodenum with the gallbladder and the cystic duct is suggestive, and studies are now under way to determine, if possible, the absorptive route and the factors underlying the contraction of these biliary channels.

#### SUMMARY

The gross and microscopic anatomy and the motor activity of the extrahepatic biliary tract in the common bullhead are reported. In this animal, the gallbladder hangs relatively free from the liver and may readily be exposed by slight traction on the duodenum, so that continuous observations on the emptying of the gallbladder in response to a meal of fat are readily made. A method is described for properly aerating the animal and exposing the viscera preparatory to such continuous observation.



3 Controls—(a) *Staphylococcus aureus* Three of the four joints in this group were opened. Two showed pus in the joint, a large fibrous tissue reaction in the joint and a roughening of all bony surfaces. One was opened seven months after the infection. This showed a large amount of fibrous tissue in the joint with evidence of new bone formation. All the cartilage had been destroyed. Trunk pus was not encountered.

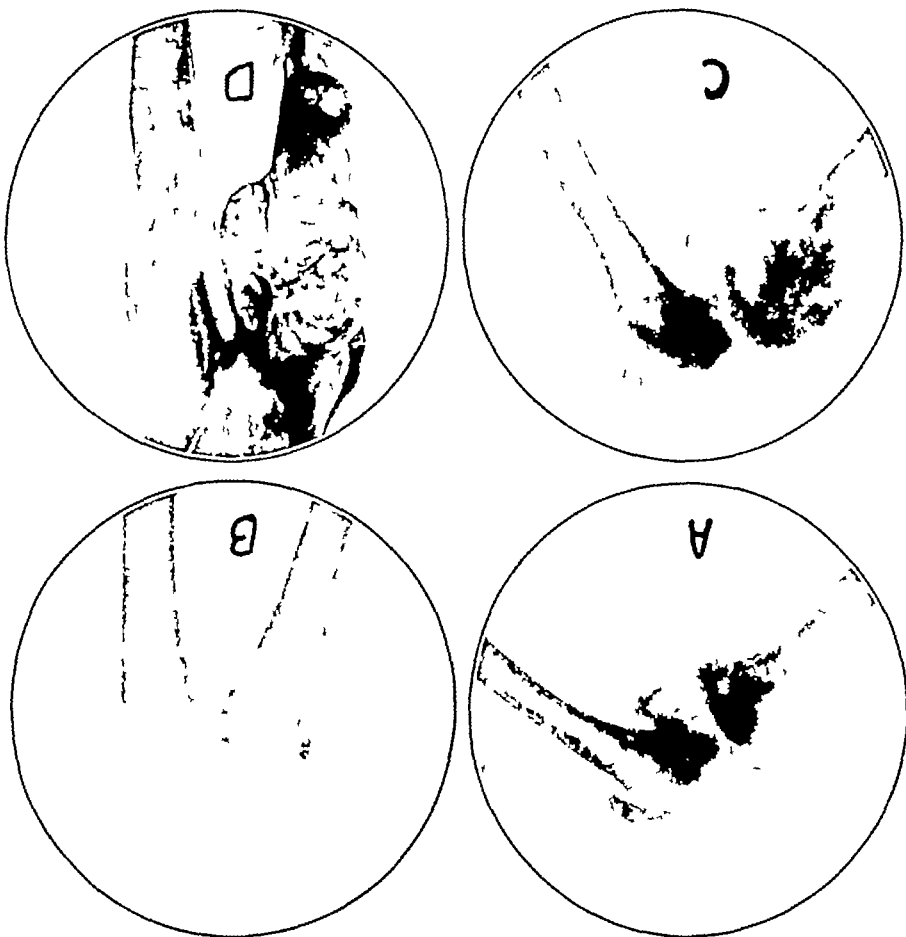


Fig. 5—Most marked roentgen-ray changes in a successfully sterilized, an unsuccessfully sterilized and a control joint infected with *Staphylococcus aureus*, and the extra-articular caseous nodules found in many of the infected joints. A indicates a sterile joint of rabbit 5 on the eighty-sixth day—0.25 per cent aqueous gentian injected, B, unsterile joint of rabbit 10 on seventy-sixth day—0.25 per cent aqueous gentian injected, C, control joint of rabbit 1 infected with *Staphylococcus aureus*, on thirty-seventh day, D extra-articular caseous nodules in rabbit 1 on thirty-seventh day. The following points should be noted (1) the clouding, irregularity and bone destruction in A, B and C, (2) the areas of absorption in B, and (3) the thinning of the lower end of the femur and thickening of the upper end of the tibia in C.

(b) Gentian Violet These three were opened and found to have a small amount of gentian in the surrounding tissues. Changes had not occurred in the joints.

Following the intraduodenal injection of a few cubic centimeters of egg-yolk and cream, active peristalsis and antiperistalsis of the gastro-intestinal tract are induced. Hepatic bile is discharged into the duodenum, but the gallbladder remains inactive during the period of gastro-intestinal activity.

Within periods of time varying from an hour and fifteen minutes to an hour and forty-five minutes, muscle tonus over the gallbladder is apparent. Contraction waves soon pass over the vesicle and force out portions of the contained bile into the common bile duct. These waves originate within the upper portion of the bile duct near its continuity with the gallbladder and pass in a reverse direction over it. Likewise, contraction waves pass over the entire common bile duct and force the contained bile into the duodenum. Subsequently, contraction waves arise at the fundus of the gallbladder and pass over the vesicle to the bile duct. Waves of the common duct and waves of the gallbladder tunic are not necessarily synchronous.

There is conclusive evidence that (1) the gallbladder in the common bullhead empties by the contraction of the muscle tunic within its wall, (2) the emptying of the gallbladder is related to the extent of gastro-intestinal absorption of fat, (3) intra-abdominal pressure is not a factor in the discharge of bile from the gallbladder, and (4) duodenal peristalsis or duodenal muscle tone is entirely ineffectual in the in the discharge of bile from the gallbladder.

## MICROSCOPIC PATHOLOGIC STUDY

The data for the microscopic pathologic study is based on the sections of nineteen out of the twenty-seven joints. Only the general results will be given.

1 *Successfully Sterilized*—(a) and (b) 0.25 Per cent Aqueous and Dextrose Gentian. Six of the nine joints were studied. Pus was found in the joints of five and in the tissues of three. In one there were three abscesses in the epiphysis of the tibia. The cartilage was eroded on the surface of the tibia in all and on the femur in all except one. In one the cartilage was found in the joint. In one, the cartilage showed a proliferation, while in another one the fibrous tissue was replacing the cartilage. There was a moderate fibrous tissue reaction in the joints of four. In one there was a definite increase of the fibrous tissue in the popliteal space. In four the bone marrow in the epiphysis was supplanted by fibrous tissue. In one there was a heavy fibrous band across the joint. The crucial ligaments and patella were normal in two. In one spicules of bone were present in the joint, with bony projections into the joint not covered by cartilage or fibrous tissue. Gentian was found in the joint of one and in the surrounding tissues of three.

(c) 0.5 Per cent Dextrose Gentian. One of the four was studied. This was five and one-half months after the infection. Pus was found in the tissues. There was an erosion of cartilage on all the joint surfaces with sequestration into the joint. Parts of the joint showed bony spicules projecting into the joint space, completely denuded of cartilage. There was evidence of cartilage proliferation. A large amount of fibrous tissue was present in the joint with an increase in the popliteal space. The crucial ligaments were thinned. The reaction showed healing.

(d) 0.5 Per cent Olive Oil Gentian. All four joints were studied. The joint reaction was more marked here than in any other group. Pus was present in the joints of three and in the surrounding tissues of one. There was an abscess in the femur of one. The cartilage of both the femur and tibia was eroded in all four with a sequestration of small bits into the joint. In one spicules of bone were present in the joint. In two the cartilage on the anterior surface of the femur was not eroded. A marked fibrous tissue proliferation was seen in all. In three fibrous tissue replaced cartilage, while in all four the bone marrow of the epiphyses was replaced with fibrous tissue. The posterior part of the capsule and crucial ligaments were thicker than normal in one.

2 *Unsuccessfully Sterilized*—Two of the three were studied. A large amount of pus was found in the joints and tissues. Abscesses were present in the bone, one showing the femur and tibia involved and the other, only the tibia. One showed a large collection of pus beneath the periosteum on the anterior border of both the femur and the tibia. The cartilage was eroded over all the joint surfaces, and had sequestered into the joint. A marked fibrous tissue proliferation was present through the joints. In one cartilage was replaced by fibrous tissue, while in another the bone marrow was supplanted by fibrous tissue.

3 *Controls*—(a) *Staphylococcus aureus*. Three of the four were studied. One of these showed only a moderate reaction while the other two showed the most marked reaction in the series. The first showed a slight amount of pus and

# PYOGENIC ARTHRITIS IN THE KNEE JOINT OF RABBITS

## TREATMENT WITH GENTIAN VIOLET EXPERIMENTAL STUDY \*

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One of the frequently discussed problems of the present day is the use of gentian violet and mercurochrome in the treatment of disease and infection. The type of infection treated has not been limited to one group of cases. The exact nature of the reaction of these drugs in combating infection has not been satisfactorily explained. With this thought in mind, a study has been made of the reaction of gentian violet in joints infected with *Staphylococcus aureus*. This study has involved a careful investigation of this type of arthritis, and it is hoped that some light may be thrown on arthritis in general.

Churchman has published three articles on the treatment of infections of the joint with gentian violet. First, in 1915, he<sup>1</sup> demonstrated an apparatus for the irrigation of a joint, followed by an instillation of gentian violet. He felt that in joints with a purulent infection the synovial membrane should be cleared of the film of pus and necrotic tissue present before the instillation of the gentian violet. The gentian violet in a 1 to 10,000 solution could then penetrate the synovial membrane to destroy the organisms. In 1918, he<sup>2</sup> reported the perfected apparatus for joint lavage, and eight cases, in two of which successful results were obtained in pyogenic joints. In 1921, he<sup>3</sup> reported six cases, in two of which good results were obtained in staphylococcus infections. In 1924, Churchman<sup>4</sup> stated that the most striking characteristic of gentian violet was its bacteriostatic power, in addition to its bactericidal power. Its great value lay in its penetration into tissues, which is impossible for antiseptics not in the triphenyl methane group of dyes. He showed that in a human knee the dye stained the nucleus and protoplasm of the endothelial cells and penetrated to the underlying connective tissue, but did not injure the synovial membrane. He showed this in an infected joint treated first with lavage.

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\* From the Louise Bowles Foundation of the Children's Hospital School, Baltimore.

1 Churchman, J. W. Ann Surg **62** 409, 1915.

2 Churchman, J. W. Treatment of Acute Infections of Joint, J. A. M. A **70** 1047 (April 13) 1918.

3 Churchman, J. W. Gentian Violet in Treatment of Purulent Arthritis, J. A. M. A **75** 583 (Aug. 28) 1921.

4 Churchman, J. W. J. Urol **11** 1, 1924.

erosion of cartilage, while the only evidence of fibrous reaction was a band across the joint. The latter two showed a large amount of pus in the joints with a slight amount in the tissues. Two large abscesses were seen in the tibia of one. There was marked cartilage erosion with sequestration into the joint. One showed spicules of bone in the joint. The fibrous tissue in the joint was marked. In one a heavy fibrous band ran across the joint. In both bone marrow was replaced with fibrous tissue.

(b) Gentian Violet. Little reaction was noted in the three. All showed an infiltration of leukocytes into the joint, and two showed a small amount of gentian. In the surrounding tissues of one gentian was found, and in another, an infiltration of leukocytes.

In summarizing the microscopic pathology four groups of changes have been noted

- (1) Acute inflammatory changes, such as pus and necrotic tissue in the joint and in the perarticular tissues, abscess formation around the joint, in the joint and in the bone proper, and pus beneath the periosteum of the bone.
- (2) Cartilaginous changes, such as erosion, destruction and sequestration into the joint, and proliferation.
- (3) Bony changes, such as spicules of bone projecting into the joint, and sequestration.
- (4) Fibrous tissue changes, such as extreme proliferation through the joint, bands across the joint, a thickening of the popliteal tissues and a replacement of cartilage and bone marrow with fibrous tissue.

#### COMMENT

In the bacteriologic study of the successfully sterilized joints, the group in which 0.5 per cent dextrose gentian was used was sterilized the most quickly, the average time being three days. In two of the four joints, the cultures were sterile in twenty-four hours after the injection of the gentian violet. An explanation of this is that the injections of the gentian followed promptly after the infection, and that 4 per cent dextrose as a medium is more efficient than water or olive oil. In the joints in which 0.25 per cent dextrose gentian was used, the average time of sterilization was thirteen days. In these the injection of gentian did not follow the infection as promptly as in the joints in which 0.5 per cent dextrose gentian was used. In the joints treated with 0.25 per cent aqueous gentian, the average time of sterilization was twenty-one days. Again the gentian was not given as promptly after the infection and the medium for the gentian was not felt to be as efficient as 4 per cent dextrose. When 0.5 per cent olive oil gentian was used, the average time of sterilization was twenty-two days. With this group the gentian was injected promptly after the infection, but the varying factor was the medium. The aspirations showed that the olive oil gentian remained in the joints longer than in the other sterile groups,



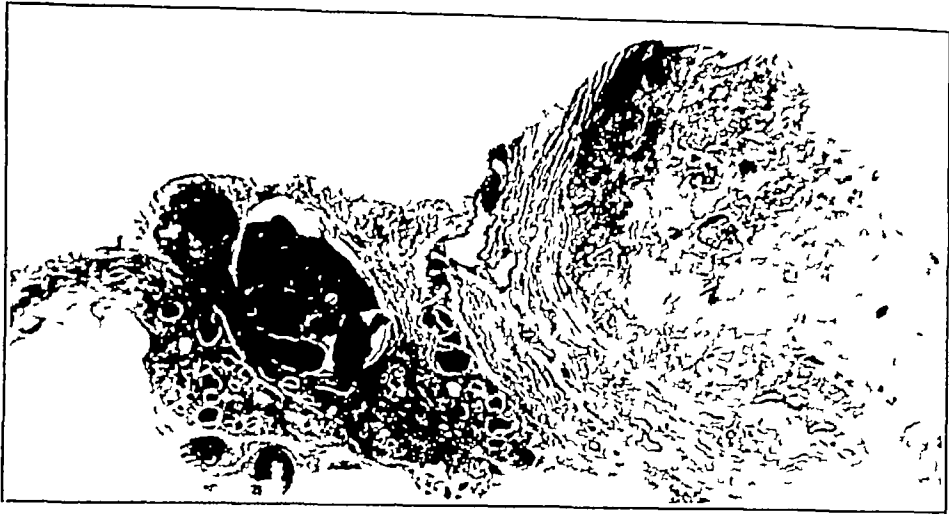


Fig 20—Cross-section of lobe of thyroid gland from patient, aged 60, operated on for nodular goiter with hyperthyroidism. In the right half of the section can be seen a large area of pin staining material surrounded by a rim of hyperplastic thyroid parenchyma. It is apparently encapsulated, but it is seen that the apparent capsule is composed of compressed normal thyroid tissue intervening between the interlobular and intralobular septums. The center of the tumor mass on the right side is made up of fibrous tissue and colloid-like material in which fragments of disintegrated acini can be seen. The nodules to the left are localized apparently encapsulated areas of dilated colloid containing acini. In this picture on the left side one has a typical area of hyperinvolution and on the right side one has a nodule hypertrophy and hyperplasia of the remaining intact parenchyma together with the central degeneration characteristic of involution, the two processes running hand in hand. Reduced from a magnification of  $\times 4$ .

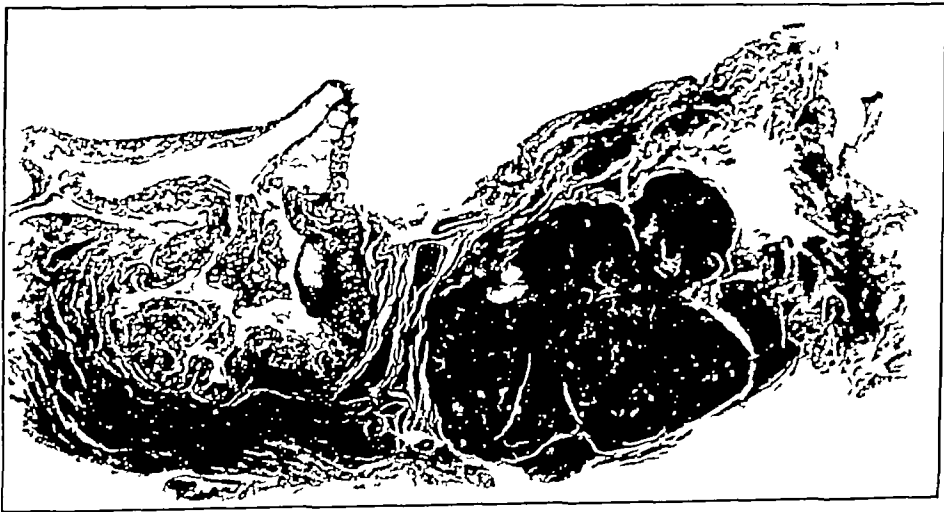


Fig 21—Cross-section of lobe of thyroid tissue from case of nodular goiter with hyperthyroidism showing two localized and sharply defined areas or nodules in which there is hypertrophy and hyperplasia of the epithelium associated with involutional changes. The normal thyroid parenchyma is displaced and compressed between the nodules appearing to form a capsule. The disease process here is localized to these areas. Reduced from a magnification of  $\times 5$ .

so that it must be assumed that the amount of gentian necessary to combat the infection quickly was not available

In the clinical study of the successfully sterilized joints, the group treated with 0.5 per cent dextrose again stands out as the best in the series. The average limitation of extension was 57 degrees and the average amount of swelling a little less than fair. When 0.25 per cent dextrose was used the average limitation of extension was 85 degrees, and the average amount of swelling slightly more than fair. One joint in this group showed only a slight reaction, with 10 degrees' limitation of extension. The 0.25 per cent aqueous method gave an 87 degree limitation of extension with the amount of swelling being fair, while the 0.5 per cent olive oil method gave the same 87 degree limitation of extension with the swelling slightly more than fair. In the gentian controls, there was an average limitation of extension of 7 degrees. In a separate experiment in which guinea-pigs were used, it was shown that there was a definite limitation of motion and proliferation of fibrous tissue after the injection of gentian violet in strengths of 1 to 200 (0.5 per cent), 1 to 100 (1 per cent) and 1 to 50 (2 per cent). In the unsuccessfully sterilized group, there was an average limitation of extension of 127 degrees with an average amount of swelling of slightly more than moderate, while the *Staphylococcus aureus* controls showed an average of 117 degrees' limitation of extension, with a moderate amount of swelling. The difference in motion and swelling in these groups may have been within the limits of variation, however, the greater reaction in the unsuccessfully sterilized joints may have been accounted for by the reaction of the gentian violet on the joint structures, in addition to the reaction of the infection.

The roentgen-ray changes in the joints in which 0.5 per cent dextrose was used were negligible, there being only a slight clouding of the joint. The changes after the 0.25 per cent aqueous treatment and after the 0.25 per cent dextrose treatment were striking, but less marked after the latter. The largest amount of bone destruction was found in the joints in which 0.5 per cent olive oil was used. This group took the longest time for sterilization, hence, there was a greater opportunity for the infection to create the bone changes. The unsuccessfully sterilized joints and the *Staphylococcus aureus* controls showed the same amount of bone destruction as the sterilized joints in which 0.5 per cent olive oil gentian was used. The gentian controls did not show roentgen-ray changes.

The gross pathologic changes corresponded closely to the clinical and roentgen-ray observations. In general, those joints which showed marked bone destruction in the roentgenograms and clinically extreme limitation of motion were found to have acute inflammatory changes, a marked fibrous tissue reaction and both cartilage and bone erosion.



tion of the patella There was a marked destruction of all cartilage with a roughening of the bone A small depression was seen in the intercondylar space Gentian tinted caseous material was found in the popliteal space extending up toward the joint

Microscopic examination of a poor section of the right knee disclosed the following Joint outlines could not be determined There was an infiltration of pus with an engorgement of the vessels in the muscles There was one large abscess fairly well encapsulated

RABBIT 11—Sex, female, weight, 2 pounds, 10 ounces (1.25 Kg), age, 4 months Injection of right knee with 0.1 cc of a twenty-four hour broth culture of *Staphylococcus aureus* on Jan 21, 1926

Day 1 Right knee showed moderate amount of swelling, with increase in local heat and 20 degrees' limit to extension

Day 6 Joint showed slight tenderness, increase in local heat and 75 degrees' limit to extension, with tenderness Culture from joint positive

Day 9 Joint showed a definite increase in the amount of local heat with about same swelling and slightly less motion

Day 28 Knee showed tumor swelling on outer lower quadrant, with tenderness marked The rabbit squealed on manipulation of the joint Motion not beyond 110 degrees' extension Weight, 2 pounds, 7 ounces (1.1 Kg) Culture from joint positive

Day 36 Knee showed marked nodular swelling, especially over the outer lower quadrant, extending down the leg Motion was limited to 120 degrees There was an increase in local heat and tenderness Weight, 2 pounds, 9 ounces (1.2 Kg) Roentgenogram showed a marked destruction about the joint, with a thinning of the condyles of the femur and thickening of the upper end of the tibia, also roughening of the under surface of the patella with small loose pieces of bone in the popliteal space

Day 42 (autopsy) Culture from joint positive

There were small nodular masses on the outer side of the right knee There was a contracture of the knee to 90 degrees and of the hip to the same, with contraction of both the hamstrings and the quadriceps The right knee was now opened across the patellar tendon The cartilage was denuded over all the condyles, with a roughening of the bone Creamy pus was present in a trabeculated sac in the joint, with much fibrous tissue and new bone formation in the joint

Microscopic examination of a fair section of the right knee revealed the following There was a slight amount of fibrin and pus in the joint The crucial ligament stood out clearly and seemed thickened There was a slight erosion of the cartilage of the tibia, that of the femur seemed almost normal The patella was intact There were several loose pieces of bone in the joint The joint was marked by the absence of a fibrous reaction The inflammatory process was in the stage of healing

RABBIT 12—Sex, male, weight, 3 pounds (1.4 Kg), age, 4 months Injection of right knee with 0.1 cc of a twenty-four hour broth culture of *Staphylococcus aureus* on Jan 21, 1926

Day 1 There was a slight swelling with no tenderness, increase in local heat or limitation of motion in the knee

Day 6 The right knee showed a slight amount of swelling, with limitation of 45 degrees' extension Culture showed heavy growth of organisms

Day 9 The right knee was more swollen with increase in local heat and limitation of motion

The one joint opened in the group treated with 0.5 per cent dextrose did not show any disease. This, however, was not typical of this group, for a second joint, sectioned but not opened, showed a moderate erosion of cartilage and bone.

The microscopic pathologic changes were markedly less in the successfully sterilized joints than in the unsuccessfully sterilized ones. The joints in which 0.5 per cent olive oil was used showed by far the most changes in the sterile joints, there being erosion of cartilage, sequestration of bone and a large proliferation of fibrous tissue. The fibrous tissue proliferation presented one of the most interesting pictures of the microscopic study. This was found through the joints, diffusely scattered and in bands, it had caused a thickening of the capsule, and, in places, both the cartilage and bone marrow were replaced by fibrous tissue. The formation of abscesses in the epiphyses of the tibia and femur was striking. Some of these abscesses apparently started in the joint and eroded through the cartilage into the bone. These were found more often in the tibia than in the femur.

#### SUMMARY

It has been shown experimentally that *Staphylococcus aureus* infections of the knee joints of rabbits can be controlled, in 85 per cent of the cases, with injections of gentian violet into the joints. The knees can be sterilized if the gentian violet is injected promptly and adequately after the onset of the infection. The more quickly the infection is controlled, the less extensive the joint changes. The gentian violet itself causes a certain amount of irritation and reaction in the joints. Four per cent dextrose is found to be a more efficient medium for the gentian violet than sterile water or olive oil. It is not believed that injections of gentian violet alone should be resorted to in the treatment of joints infected with *Staphylococcus aureus*, but that this treatment should supplement proper surgical measures for the eradication of the infection.

#### CONCLUSIONS

1. Gentian violet has a definite effect in allaying infections with *Staphylococcus aureus* in the knee joints of rabbits.

2. Gentian violet, if administered early enough and in sufficient quantities, will sterilize the joints.

#### PROTOCOL OF RABBIT EXPERIMENTS

RABBIT 1—Sex, male, weight, 2 pounds, 7 ounces (1.1 Kg), age, 3 months. Injection of right knee with 0.1 cc of a twenty-four hour broth culture of *Staphylococcus aureus* on Dec 21, 1925. Roentgenograms taken of both knees.

Day 1. Right knee was definitely swollen, with increase in local heat, and slight limitation of motion. There was evidence of tenderness with the right leg held up on walking. Rabbit looked toxic.

Day 28 There was a moderate amount of swelling with 110 degrees' limit to extension, with marked tenderness. The rabbit squealed on manipulation to extension, no growth.

Day 36 There was now 120 degrees' limit to extension, with swelling about

the same. Rabbit walked with the leg drawn up. Weight, 2 pounds, 9 ounces (11 Kg). Roentgenogram showed marked irregularity of joint surfaces, with

thinning of the condyles of the femur and thickening of the tibia, roughening on the under surface of the patella and small pieces of bone in the popliteal space.

Day 42 (autopsy) Pus was not visible in the tissues and there were no nodules, as in the other control rabbits. The extension of the hip and knee was limited to 90 degrees. When the joint was opened creamy yellow pus with some gelatinous material was found. The cartilage was pretty much destroyed, with

roughening of the condyles of the femur. There was fibrous tissue in the joint.

Microscopic examination of a section of the right knee showed a marked irregularity of all joint lines with a rather generalized destruction of the cartilage. Areas on the tibia and femur showed definite bone involvement and destruction. The joint was filled with pus and fibrin, with a large amount of fibrous tissue all through. Bands of fibrous tissue were seen between the femur and tibia. Islands of cartilage cells were found in the fibrous tissue. Abscesses were not made out in the bone. The patella showed an irregularity of the under surface, with evidence of fibrous tissue. Leukocytic infiltration was present through the surrounding tissues. There was a large amount of pus and fibrous tissue in the popliteal space. The bone marrow in places had been supplanted by fibrous tissue. The inflammatory process was still in a fairly acute stage.

Rabbit 13—Sex, female, weight, 3 pounds (14 Kg), age, 3½ months. Injection of right knee with 0.1 cc of a twenty-four hour broth culture of *Staphylococcus aureus* on March 1, 1926.

Day 1 Right knee showed definite increase in local heat, with swelling and 5 degrees' limit to motion. Culture from joint showed good growth. Injection of 1 cc of 0.25 per cent devtrose gentian heated to 55 C (131 F).

Day 4 Right knee showed a large amount of swelling, with increase in local heat and crepitation of the joint. Motion limited to 110 degrees. Culture from joint positive. Aspirated thick purple material. Roentgenogram showed a slight clouding of the joint.

Day 5 Joint showed same amount of swelling, with 120 degrees' limit to full extension. Injection of 1 cc of 0.25 per cent devtrose gentian.

Day 10 Joint showed same reaction. Weight, 2 pounds, 12 ounces (12 Kg). Culture from joint positive.

Day 28 Joint was moderately swollen, with evidence of fibrous reaction about, and limit of 135 degrees' extension. Culture from joint showed growth.

Day 32 The knee showed the same motion and swelling, with an additional soft fluctuant swelling below the knee.

Autopsy Culture from right knee positive.

There were many caseous nodules surrounding the right knee with purulent material softer than that in the ones previously reported. There was a marked contraction of the hamstrings preventing extension beyond 135 degrees. Some gentian was found in the caseous material in the popliteal space. The joint was not opened.

Microscopic examination of a section of the right knee showed clearly the destruction and fibrous tissue reaction in the joint. Several large encapsulated abscesses were seen anterior to the head of the tibia. There was a marked erosion of the cartilage along the anterior and posterior parts of the femur and

Day 2 Joint now showed increase in limitation of motion of approximately 70 degrees Swelling was about the same, with slightly less tenderness and local heat

Day 3 Joint showed about the same reaction Culture from joint positive Aspirated milky turbid fluid Roentgenogram of right knee showed a slight haziness about the posterior part of the tibia

Day 5 Right knee showed an increase in the swelling, with the same amount of motion Swelling had extended down the leg to the midpoint of the ankle Limp was still marked but not as sensitive to the touch Culture from joint showed luxuriant growth

Day 6 Joint showed same motion and swelling

Day 10 There was a marked increase in the swelling which was nodular in character about the joint, with 105 degrees' limitation of motion There was evidence of fluid in the joint, with fluctuancy The rabbit looked quite sick and emaciated Weight, 2 pounds, 4 ounces (1 Kg) Culture from joint positive Roentgenogram showed an irregularity of the tibia and femur with the joint distended and the patella lifted up, showing an irregularity on the inferior surface

Day 11 The swelling about the knee was much more marked, with only 20 degrees of motion possible, there being a limitation of 120 degrees of extension The rabbit looked sicker and more emaciated The left knee now showed a limit of the last 20 degrees of extension Culture from joint positive

Day 22 There was now a nodular swelling down the leg to the ankle joint, as well as that about the joint Motion the same

Day 37 (autopsy) Culture from right knee positive for *Staphylococcus aureus* Roentgenogram of the right knee showed marked destruction of all the joint surfaces with a destruction of the condyles and a few bony projections about these also new bone formation about the head of the tibia

The right knee presented a cauliflower-like appearance, with multiple yellowish abscesses beneath the muscular fascia extending from the upper limit of the quadriceps pouches to the lower third of the tibia The joint could not be extended beyond 135 degrees There was a string of fibrous tissue running from the abdominal wall to the knee, holding it up in flexion The joint was not opened

Microscopic examination could not be performed because the specimens were lost

RABBIT 2—Sex, male, weight, 3 pounds (1.4 Kg), age, 3 months Injection of the right ear vein with 0.1 cc of a twenty-four hour broth culture of *Staphylococcus aureus* on Dec 21, 1925 A small dentist's drill was then used to traumatize the right knee, this being put into the joint and moved around in all directions with the drill revolving Roentgenograms were taken of both knees, they were negative

Day 1 The right knee showed a slight limitation to full extension, with a slight amount of swelling There was no increase in local heat with no limp on walking The rabbit, however, looked quite toxic

Day 2 General condition of the rabbit about the same with no change in the knee

Day 3 The right knee showed a limitation of 10 degrees to full extension No swelling The rabbit was more toxic Roentgenogram of the right knee showed a slight haziness behind the tibia

Day 5 Right knee showed same amount of motion with slight amount of swelling The animal looked more toxic and much less lively

over the top of the tibia. A great deal of fibrous tissue was observed through the joint, in parts of which were nests of cartilage cells. Fibrous tissue had completely replaced the cartilage along the borders of the femur. A large fibrous band was found across the joint at one side. Pus and fibrin were seen all through the joint. The anterior border of the tibia was eroded by an abscess which had arisen in the soft tissue. The fibrous tissue was supplanting the bone marrow in places. The inflammatory process was one which was subsiding.

RABBIT 14—Sex, male, weight, 3 pounds, 8 ounces (1.6 Kg.), age,  $3\frac{1}{2}$  months. Injection of right knee with 0.1 cc of a twenty-four-hour broth culture of *Staphylococcus aureus* on March 1, 1926.



Fig 7—High power photomicrograph of section from rabbit 13. Autopsy on thirty-second day after infection. Joint culture positive. Joint received two injections of 0.25 per cent devtrose gentian violet. Margin of cartilage erosion with island of cartilage surrounded by fibrous tissue, fibrous tissue proliferation in the joint space and fibrous tissue replacing the cartilage of the bone marrow.

Day 1. Right knee showed a marked increase in local heat, with some swelling and 5 degrees' limit to full extension. Rabbit seemed fairly toxic. Culture showed good growth. Injection of 1 cc. 0.25 per cent devtrose gentian at 55 C (131 F). Day 4. Joint showed moderate amount of swelling, with 100 degrees' limit to extension, with increase in local heat and crepitation. Culture from joint positive. Roentgenogram showed no changes.

Day 6 Right knee showed slightly more swelling with slightly more limitation to full extension. Otherwise rabbit was the same.

Day 10 Rabbit looked quite emaciated, having lost 15 ounces (0.5 Kg) in ten days, and seemed toxic. There was now an ankylosis of the right knee in about 75 degrees' flexion, with only a slight amount of swelling. The animal squealed when the left knee was touched, there being a slight amount of swelling and a limitation of the last 20 degrees of extension. Culture from right knee positive. Roentgenogram of the right knee showed a clouding behind the tibia and in the supracondylar region in front.

Day 11 The right knee seemed slightly more swollen and fluctuant, but the general condition of the rabbit was the same.

Day 15 (autopsy) The rabbit died after being much more toxic during the preceding two days. Culture from right knee joint positive for *Staphylococcus aureus*. Culture from heart's blood positive for *Staphylococcus aureus*. Roentgenogram of the right knee showed about the same clouding with small shadows in the anterior joint space.

The rabbit was extremely dehydrated. The right knee was ankylosed at an angle of 75 degrees, with no evident swelling. When the joint was opened, the surfaces were found to be dull and covered with a sticky purulent exudate. The joint was not examined closely. Small abscesses were found in the liver, kidneys, chest wall and leg muscles.

Microscopic examination of a section from the right knee revealed a marked irregularity of the opposing joint surfaces with a destruction in spots of the cartilage. Two abscesses were present in the tibia, one in the epiphyseal line proper and the other in the epiphysis. There was a rather marked leukocytic infiltration with necrotic tissue in the joint and surrounding tissues. An abscess was seen in the opposing surface of the femur. This seemed to open into the joint. The cartilage destruction was certainly more marked over the opposing surfaces of the femur and tibia. There was a rather marked accumulation of pus in the popliteal space with a distention of the capsule in this region. This joined the abscess in the femur.

RABBIT 3—Sex, female, weight, 2 pounds, 9 ounces (1.1 Kg), age, 3½ months. Injection of right knee, Dec. 28, 1925, with 0.1 cc of twenty-four hour broth culture of *Staphylococcus aureus*.

Day 1 Right knee showed a small amount of swelling, with 10 degrees' limitation of extension and definite increase in local heat. The joint was aspirated, and a luxuriant growth was obtained. Injection of 1 cc. of 0.25 per cent aqueous gentian violet into right knee. Roentgenogram showed a slight clouding about the condyles.

Day 2 Right knee showed the same amount of swelling and motion.

Day 3 No change. Aspiration of joint showed a positive culture.

Day 4 The right knee showed a fair amount of swelling, and 30 degrees' limitation of full extension. Injection of 1 cc. of 0.25 per cent aqueous gentian

Day 10 Right knee showed same amount of swelling and motion. Aspiration showed a positive culture. Injection of 1 cc 0.25 per cent aqueous gentian. Roentgenogram showed a clouding about all of the joint lines but no destruction of bone.

Day 21 Right knee showed moderate amount of swelling, with 120 degrees' limitation of extension. Aspiration showed a negative culture. Roentgenogram showed a destruction of the opposing joint surfaces of the tibia, femur and patella, with a marked clouding.

Day 5 Joint showed slightly less motion, about 120 degrees' limitation, with same swelling and increase in local heat. Injection of 1 cc of 0.25 per cent dextrose gentian

Day 10 Joint showed same changes. Weight 2 pounds, 13 ounces (1.2 Kg.)

Culture from joint did not show growth

Day 28 Right knee showed a surrounding fibrous reaction, with moderate swelling and 135 degrees' limit to motion. Culture from joint positive

Day 32 Knee showed same swelling and motion. Weight 2 pounds, 10 ounces (1.15 Kg.)

Autopsy Culture from joint positive

Several caseous nodules tinted with gentian were found about the joint and in the popliteal space. There was a contraction of the hamstrings. A large amount of bony swelling in the joint could be palpated. The joint was not opened.

Microscopic examination of section of the right knee revealed the following. This was another section which showed well the reaction and destruction of



Fig 8—Photomicrograph of section from rabbit 14. Autopsy on thirty-second day after infection. Joint culture positive. Joint received two injections of 0.25 per cent dextrose gentian violet. Four distinct abscesses in epiphysis of femur, an abscess behind the head of the tibia, a necrosis of the posterior portion of the epiphysis of the tibia, pus along the anterior margins of the femur and tibia and pus with necrotic tissue in the joint space. This is the section of roentgenogram D in figure 4.

the joint. Abscesses were seen in the popliteal space and in the epiphysis of both the tibia and femur. Those in the femur were linked together and were about four in number. There was a marked fibrous reaction through the joint with pus and fibrin. A layer of pus was seen along the anterior border of both the femur and the tibia. Small islands of cartilage were embedded in the fibrous tissue and pus. There was a destruction of all the cartilaginous surfaces, but it was more marked on the femur. A small sesamoid bone was found in the popliteal space adjacent to an abscess. The bone marrow was supplanted in places by fibrous tissue. The reaction in the joint was that of a fairly acute inflammation.

Day 23 (autopsy) Culture of right knee was negative Roentgenogram of right knee showed the same bone destruction as previously reported

There was about 120 degrees' limitation of full extension, with a moderate amount of swelling There was an infiltration of gentian beneath the muscle on the outer side of the tibia for almost its whole length There were many small yellowish areas over the head of the tibia suggesting tiny abscesses in the muscles and fascia A definite contracture of the hamstrings was found When the knee joint was opened, a large amount of grumous purplish material was found, with a large amount of fibrous tissue throughout Some roughening of the bony surface was noted

Microscopic examination of a section from the right knee revealed remarkably well preserved joint lines, considering the amount of reaction There was a large amount of fibrous tissue in the joint, with gentian and leukocytes On the cartilaginous surfaces of the femur and tibia, deposits of leukocytes, fibrin and necrotic tissue were present The crucial ligaments were preserved and had the same deposits A rather heavy fibrous band ran through the joint There was a thinning and destruction of the cartilage in spots There was one area which suggested a proliferation of cartilage somewhat similar to a chondrosarcoma A large amount of gentian and necrotic material was found through the muscles The cartilage was eroded over the popliteal surface of the femur with beginning abscess formation in the femur There were a few deposits of leukocytes and necrotic material through the adjacent area of the bone marrow

RABBIT 4—Sex, female, weight, 2 pounds, 12 ounces (12 Kg), age, 3½ months Injection of right knee with 0.1 cc. of a twenty-four hour broth culture of *Staphylococcus aureus* on Dec. 28, 1926

Day 1 Right knee showed a slight limit to full extension, with no swelling or increase in local heat There was a slight limp

Day 2 Knee showed the same condition Injection of 1 cc 0.25 per cent aqueous gentian Roentgenogram showed a slight clouding and irregularity behind the condyles of the femur

Day 3 The joint had a slight limitation to full extension, about 15 degrees, with slight swelling Culture from joint showed good growth

Day 4 The joint showed the same limitation of motion and swelling

Day 5 (autopsy) The rabbit died after a severe, acute diarrhea with prostration Culture from right knee joint positive Culture from heart's blood showed *Bacillus hofmanni* Roentgenograms of the right knee showed a clouding about the joint, especially of the lower femur

On examination, the right knee showed about 15 degrees' limitation to full extension, with a fair amount of swelling When the knee was opened, a large amount of thick creamy pus was found, which extended up into the quadriceps pouches The joint surfaces were not carefully examined There was no evidence of abscess in any other part of the body

Microscopic examination of a section from the right knee revealed a remarkably small amount of reaction in the joint A fair amount of pus and fibrin was present but there was no fibrous tissue in the joint The cartilage of the tibia and femur did not show erosion The patella and semilunar cartilages were intact The subpatellar fat pad was well shown and there was no reaction There was a moderate engorgement of vessels and leukocytic infiltration in the surrounding tissues The inflammatory process was not far enough advanced in this region to be acute



RABBIT 15—Sex, male, weight, 2 pounds, 15 ounces (14 Kg), age, 4 months. Injection of the right knee with 1 cc of 0.25 per cent dextrose gentian violet on March 2, 1926.

Day 1. No reaction could be made out in the knee.

Day 5. There was a slight limitation of extension. No swelling, and no increase in local heat.

Day 32. The right knee showed a slight amount of swelling, with a limitation of the last 10 degrees of extension. Roentgenogram did not show joint changes, but a slight shadow in the popliteal space.

Autopsy. When the skin was removed, the joint had the normal healthy appearance with a gloss to the patellar tendon. When the joint was opened this was essentially normal. There was a slight roughening of the cartilaginous surfaces. All ligaments and other cartilages were normal. A small pocket of gentian was found in the popliteal space. There was about 5 degrees' limitation to extension.

Microscopic examination of the right knee disclosed the following. The cartilage was regular. There was no evidence of any reaction in the joint. A few pus cells and fibrin were present in the joint. The section was only fair.

RABBIT 16—Sex, female, weight, 3 pounds, 9 ounces (16 Kg), aged, 3½ months. Injection of the right knee with 0.1 cc of a twenty-four-hour broth culture of *Staphylococcus aureus* on March 5, 1926.

Day 1. Right knee showed a slight amount of swelling, with increase in local heat, and about 5 degrees' limitation to extension. Culture from joint positive. Injection of 1 cc of 0.25 per cent dextrose gentian.

Day 3 (autopsy). Culture from right knee positive. Roentgenogram of the right knee did not show any changes. The rabbit died without any apparent cause, with no evidence of diarrhea or prostration as seen in rabbit 4.

When the joint was removed there remained only the last 10 degrees of extension, limited, with little swelling. A fair amount of the gentian was found in the muscles of the lower thigh in the popliteal space. When the joint was opened a fair amount of the gentian was present, with an evanescent resembling inspissated pus. There was no evidence of fibrous tissue reaction in the joint. Synovial membrane seemed eroded over the condyles of the femur and beneath the patella.

A rather generalized congestion of all organs, the liver, kidneys, heart and lungs was found. A greenish stain was present over the right abdominal wall. Microscopic examination of a section from the right knee revealed a little reaction in the joint. A small amount of gentian was present and in the surrounding muscles. A few leukocytes were present in the joint and a great many in the muscles. There was a slight irregularity of the cartilage along the border of the femur. Fibrous tissue was not present in the joint.

RABBIT 17—Sex, male, weight, 3 pounds, 2 ounces (14½ Kg), age, 3½ months. Injection of right knee, March 5, 1926, with 0.1 cc of a 24 hour broth culture of *Staphylococcus aureus*.

Day 1. Right knee showed a slight amount of swelling, with an increase in local heat and 10 degrees' limitation of extension. Culture from joint positive. Injection of 1 cc of 0.25 dextrose gentian violet.

Day 6. Right knee showed a slight increase in swelling and about the same limitation of motion.

Day 20. There was about 60 degrees' limitation of extension in the knee, with a slight increase in swelling. There was a definite contraction of the hamstring.

RABBIT 5—Sex, male, weight, 2 pounds, 10 ounces (12 Kg), age, 3½ months  
Injection of right knee, Jan 6, 1926, with 0.2 cc of twenty-four hour broth culture of *Staphylococcus aureus*

Day 1 Right knee showed a small amount of swelling, with 10 degrees' limitation of extension and increase in local heat. Joint aspirated but no growth obtained. Injection of 1 cc of 0.25 per cent aqueous gentian violet.

Day 2 Right knee showed 90 degrees' limitation of extension, with a fair amount of swelling and increase in local heat.



Fig 6—Low power photomicrograph of section from rabbit 4. Died on fifth day after infection of acute diarrhea and prostration. Joint culture positive. Joint received one injection of 0.25 per cent aqueous gentian violet on second day after infection. Pus and fibrin in the joint space and a beginning indentation of the cartilage of the tibia (on the right).

Day 4 Right knee showed same amount of motion, with an increase in the amount of swelling.

Day 6 Same as last note.

Day 9 Right knee showed 75 degrees' limitation of extension, with a fair amount of swelling and increase in local heat. Aspiration showed a negative culture. Roentgenogram showed a marked clouding of the joint.

Day 26 Right knee showed 90 degrees' limitation of extension, with a fair amount of swelling. Aspiration showed a negative culture.

*[The page contains dense handwritten text in Hebrew script, which is mostly illegible due to extreme blurring and perspective.]*

Day 51 Right knee showed same amount of motion and swelling Roentgenogram showed a marked irregularity with a destruction of the joint surfaces and clouding of the joint.

Day 82 Right knee showed the same amount of motion and swelling Culture from joint negative

Day 86 Right knee showed 90 degrees' limitation of extension, with a slightly less amount of swelling and no local heat

Autopsy Culture from right knee, negative Roentgenogram of right knee showed a marked destruction of all bony surfaces with a thickening of the head of the tibia and a thinning of the lower end of the femur, with a fusiform shadow along the upper crest of the tibia

The right knee now showed only 45 degrees of limitation of full extension, with a bony hard swelling along the upper tibia and around the condyles of the femur On dissection around the joint a small fusiform purplish tinted caseous mass was found along the upper end of the tibia, which gave the roentgen-ray shadow at this point. On section this was found to be a little gritty When the joint was opened transversely a tremendous amount of fibrous tissue was found in the joint, with a roughening of the upper end of the tibia, and the condyles of the femur The semilunar cartilages and the crucial ligaments could not be clearly ascertained because of the amount of fibrous tissue

Microscopic examination of an extremely poor section from the right knee revealed the following An infiltration of leukocytes could be seen through the joint cavity and muscles, with an engorgement of the vessels The joint lines could not be determined No abscesses were seen The inflammation was apparently slight

RABBIT 6—Sex, male, weight, 2 pounds, 12 ounces (1.2 Kg), age, 3½ months Injection of right knee, Jan 6, 1926, with 0.1 cc of twenty-four hour broth culture of *Staphylococcus aureus*

Day 1 Right knee showed only a small reaction, with about 10 degrees of limitation of extension and a slight swelling

Day 4 Same as on first day

Day 9 The right knee seemed slightly more swollen, with a limitation of the last 20 degrees of extension Aspiration showed a negative culture Injection of 1 cc of 0.25 per cent aqueous gentian violet Roentgenogram showed a slight clouding about the joint.

Day 24 Right knee a limitation of the last 35 degrees of extension, with a small amount of swelling Aspiration showed a negative culture

Day 51 Right knee showed 35 degrees' limitation of extension and same amount of swelling Roentgenogram showed a slight clouding of the joint with an irregularity of the under surface of the patella

Day 82 Right knee showed limitation of last 5 degrees of extension, with slight swelling

Day 86 Right knee showed same amount of motion with a hard swelling around the condyles of the femur

Autopsy Roentgenogram showed a slight irregularity of the upper surface of the tibia, lower surface of the femur and under surface of the patella

There was a slight limitation of full extension of 15 degrees, with no perceptible swelling about the joint Gentian was not found in the tissues The joint was not opened

Microscopic examination of a section from the right knee revealed unusually clear joint lines There was a slight erosion of cartilage on the opposing surfaces, with a small amount of pus and fibrin in the joint Gentian was not seen

in the joint. The cartilages and ligaments were normal throughout. Changes could not be made out.

Microscopic examination of a section of the right knee disclosed little reaction. There were a few breaks in the cartilage of the femur and tibia which were probably artefacts. A slight amount of fibrin was found in the joint, and a small amount of gentian. There was a scssamoid bone in the popliteal space.

RABBIT 20—Sex, male, weight, 3 pounds, 12 ounces (17 Kg), age, 4 months. Injection of right knee with 0.1 cc of a twenty-four-hour broth culture of *Staphylococcus aureus* on March 11, 1926.

Day 18. Right knee showed a large amount of swelling, with increase in local heat and 100 degrees' limit to full extension. Culture from joint positive. Day 23. Knee showed large amount of swelling, especially in the outer lower quadrant of the knee, with increase in local heat and fibrous reaction about the joint. Motion limited 110 degrees. Roentgenogram showed a marked irregularity and destruction of the joint surfaces, with clouding of the joint. Day 88. The right knee showed a more marked nodular formation about the joint, with the same amount of swelling and limitation of motion. Under iodine technic one or two of the nodules were opened and the pus was evacuated. Day 115. Same method of evacuation of the caseous pus from three more nodules.

Day 128. The right knee showed the same nodular swelling with soft midpoints to the nodules. Motion was not beyond 110 degrees' extension. Day 216. There was the same nodular swelling, with pus draining from one or two points. Joint was ankylosed at an angle of 120 degrees. Day 230. The same nodular swelling was seen, with draining sinuses at two points, and a limit of 135 degrees to extension. Swelling extended into the popliteal space.

Autopsy. A large number of caseous nodules with thick purulent material about the joint extended down the lower part of the leg and into the popliteal space. The joint was large and thickened. There was a large amount of fibrous tissue and new bone formation in the joint. All the joint structures were obliterated with a complete destruction of all the cartilage. There was the barest semblance of crucial ligaments. No frank pus was found in the joint. The patella was large, thick and roughened. Some new bone formation was present in the popliteal space. The motion in the joint was from 160 to 135 degrees.

Microscopic examination of a section of the right knee showed a large number of joint changes. There were two abscesses in the head of the tibia about where the epiphyseal line should be seen. A great deal of pus and fibrous tissue was present through the joint. Cartilage was not present on the lower end of the femur or upper end of the tibia. Small fragments of bone were found in the joint. There were a few islands of cartilage separated from, but adjacent to, the tibia. The bone was eroded in spots at the lower end of the femur. Abscesses were seen in the popliteal space. The inflammatory process looked like one which was healing. The bone marrow in places had been supplanted by fibrous tissue.

RABBIT 21—Sex, female, weight, 4 pounds, 3 ounces (19 Kg), age, 6 months. Injection of right knee, April 9, 1926, with 0.1 cc of a twenty-four-hour broth culture of *Staphylococcus aureus*.

in the joint or tissues. There was a slight engorgement of the vessels. The patella apparently was normal. A slight amount of fibrous tissue supplanted the bone marrow in the femur. There was a cartilage proliferation from the popliteal side of the tibia. The inflammatory process was like one which has healed.

RABBIT 7—Sex, male, weight, 2 pounds, 14 ounces (1.3 Kg), age, 3½ months. Injection of right knee, Jan. 11, 1926, with 0.1 cc. of a twenty-four hour broth culture of *Staphylococcus aureus*.

Day 1. Right knee showed no limitation of motion, with a slight amount of swelling with no increase in local heat.

Day 4. Right knee showed a limitation of 45 degrees of extension, with a fair amount of swelling and increase in local heat. Culture from joint positive. Injection of 1 cc. of 0.25 per cent aqueous gentian violet. Roentgenogram showed a slight clouding of the joint.

Day 9. Right knee showed the same amount of motion and swelling. Culture from joint positive.

Day 10. Right knee showed the same. Injection of 1 cc. of 0.25 per cent aqueous gentian.

Day 19. Right knee showed a much more marked reaction, with 110 degrees' limitation of extension and much more swelling, with an increase in local heat. Culture from joint was negative.

Day 38. Right knee showed limitation of extension of 135 degrees, with a moderate amount of swelling. Culture from joint negative.

Day 46. Right knee showed about the same amount of motion and swelling. Roentgenogram showed a marked irregularity of all joint surfaces, with a thinning of the lower end of the femur and a clouding about the joint.

Day 52 (autopsy). Culture from right knee was negative.

The skin over the right knee showed a subcutaneous fibrous reaction. There was a limitation of 90 degrees of full extension. Caseous nodules were present about the upper end of the tibia, in the popliteal space and down the outside of the tibia. This latter was fusiform, and purplish tinted. The popliteal swelling seemed to communicate with the joint proper. When the joint was opened, the most noticeable observation was the amount of fibrous reaction and imperceptibility of the joint structures. There was an erosion of the cartilage and bone in the joint.

Microscopic examination of only a fair section from the right knee revealed the following. There was a marked irregularity of the joint surfaces with erosion of cartilage. Little cartilage remained. A large amount of fibrous tissue was seen through the joint, with pus and fibrin. One large abscess was found in the medullary cavity of the tibia and two small ones in the diaphysis close to the epiphyseal line. Gentian was not seen. One of the abscesses in the tibia apparently connected with the joint. The bone marrow in places had been supplanted by fibrous tissue. The inflammatory process was certainly still in the acute stage.

RABBIT 8—Sex, female, weight, 2 pounds, 13 ounces (1.3 Kg), age, 3½ months. Injection of right knee, Jan. 11, 1926, with 0.1 cc. of a twenty-four hour broth culture of *Staphylococcus aureus*.

Day 1. Right knee showed 10 degrees' limitation of full extension, with a slight amount of swelling, and increase in local heat. Injection of 1 cc. 0.25 per cent aqueous gentian violet.

Day 4. Right knee showed 20 degrees' limitation of extension, with a fair amount of swelling and increase in local heat. Culture from joint was positive. Roentgenogram showed a slight clouding of the joint structures.

Day 1 Right knee showed a definite increase in local heat, with a slight swelling but no limitation of motion. Culture from right knee positive. Injection of 1 cc of 0.25 per cent devtrosc gentian violet

Day 3 Right knee showed a slight amount of swelling, with 70 degrees' limitation of full extension and marked increase in local heat. Culture from joint positive. Injection of 1 cc of 0.25 per cent devtrosc gentian

Day 7 Right knee showed a much more marked swelling which had extended down the whole lower part of the leg to the ankle, with 90 degrees' limitation of extension. There was also some limitation of motion in the ankle. Culture from joint negative. Roentgenogram showed a definite clouding of the joint without destruction.

Day 10 Right knee showed a large amount of swelling, with 100 degrees' limitation of extension. There was a nodular swelling on the outer side of the joint. Culture from joint negative.

Day 19 Right knee showed less swelling, with an increase in the motion so that the extension was only limited 60 degrees. Roentgenogram showed a slight clouding and fuzziness of the joint lines.

Day 31 Right knee was almost completely normal, with only small amount of swelling and only a limitation of 10 degrees of full extension. Roentgenogram of right knee was entirely negative.

Day 123 Right knee showed only the slightest limitation of full extension, not over 5 degrees, with absolutely no swelling.

Day 211 The right knee showed normal motion, with no swelling or limit to extension.

Day 225 The right knee showed no swelling, no limit to extension and was, apparently, a perfectly normal joint. Weight, 4 pounds, 9 ounces (2.1 Kg). Autopsy There was a limit of the last 10 degrees of extension, with a slight fibrous reaction around the joint. Swelling, lateral mobility and pus nodules were not present. There was an erosion of the cartilage on the upper portion of the condyles, with island formation of bits of cartilage. The crucials were present and looked normal. The semilunars looked a little thinner than normal. There was a slight erosion of the cartilage around the top of the tibia on the edges.

Microscopic examination of a section from the right knee showed remarkably little reaction in the joint. A small amount of fibrous tissue was found in the joint. No pus in the joint but some in the surrounding tissues. The crucials were present. The cartilage was denuded in spots over both surfaces of femur and tibia. No abscess formation. Large amount of fibrous tissue in popliteal space. The cartilage had proliferated in spots. The bone marrow was sup- planted in places with fibrous tissue but this was not marked. The inflam- matory process was distinctly one which had healed.

RABBIT 22—Sex, female, weight, 2 pounds, 10 ounces (1.25 Kg), age, 3 months. Injection of the right knee, April 16, 1926, with 0.1 cc of a twenty- four-hour broth culture of *Staphylococcus aureus*.

Day 1 Right knee showed a slight increase of local heat and swelling, with 10 degrees' limitation of extension. Culture from joint positive. Injec- tion of 1 cc of 0.5 per cent olive oil gentian violet.

Day 3 Right knee showed about 60 degrees' limitation of extension, with slight amount of swelling and local heat increase. Culture from joint positive. Injection of 1 cc of 0.5 per cent olive oil gentian

Day 4 Right knee showed same amount of motion and slightly more swelling. Culture from joint positive. Injection of 1 cc of 0.5 per cent olive oil gentian

Day 9 Right knee showed same condition Injection of 1 cc of 0.25 per cent aqueous gentian

Day 11 Right knee showed more marked reaction, with only 90 degrees' extension and slightly more swollen, with swelling in nodules above the patella Culture from joint positive

Day 19 Right knee showed limitation of 120 degrees' extension, with about the same swelling and local heat Culture from joint positive

Day 21 Knee showed same condition Injection of 1 cc 0.25 per cent aqueous gentian

Day 22 Right knee showed a slight increase in swelling with same motion and increase in local heat Culture from joint negative

Day 38 Knee showed same amount of swelling and motion Culture from joint negative

Day 46 Knee now showed a limitation of 75 degrees of motion, with same swelling Roentgenogram showed a marked destruction of the joint surfaces, especially the condyles of the femur and the under surface of the patella, with a few shadows around the joint suggesting gentian infiltration in the tissues

Day 52 (autopsy) Culture from joint negative

There was a fibrous reaction in the subcutaneous tissue around the right knee with a slight adherence of the skin There were many purplish tinged caseous nodules in the fascia, and extending down into the popliteal space The joint was opened transversely A large amount of fibrous tissue in the joints bound other elements down tightly The cartilages were eroded and the bony surfaces were roughened Gentian was not found in the joint, and there was no evidence of frank pus in the joint There was a contracture of the hamstrings

Microscopic examination of a poor section from the right knee disclosed the following There was a fair amount of fibrous tissue reaction with infiltration of pus about the joint An infiltration of pus and gentian was observed in the muscles, with an engorgement of vessels

RABBIT 9—Sex, female, weight, 3 pounds, 5 ounces (1.5 Kg), age, 3½ months Injection of right knee, Jan 16, 1926, with 0.1 cc of a twenty-four hour broth culture of *Staphylococcus aureus*

Day 1 Right knee showed a slight amount of swelling, with limitation of 15 degrees' extension and increase in local heat Culture from joint positive Injection of 1 cc of 0.25 per cent aqueous gentian violet

Day 2 Right knee showed slight increase in swelling, with 20 degrees' limitation of extension and increase in local heat Culture from joint positive Roentgenogram showed a slight clouding of the joint

Day 3 Right knee showed 90 degrees' limitation of extension, with slight increase in swelling

Day 4 Right knee showed same size and amount of motion Injection of 1 cc 0.25 per cent aqueous gentian

Day 6 Right knee showed 100 degrees' limitation of extension, with swelling well up into the suprapatellar pouches Culture from joint positive

Day 14 Right knee had a limitation of 120 degrees' extension, with swelling more marked, there being nodules to the medial side of the joint Culture from joint positive

Day 33 Right knee showed 100 degrees' limitation of extension, with moderate amount of swelling Reaction was less than last note Culture from joint showed only one colony of *Staphylococcus aureus*



Day 6 Right knee showed 80 degrees' limitation of extension, with same amount of swelling and local heat increase. Culture from joint positive.

Day 7 Knee showed 100 degrees' limitation of extension, with same amount of swelling. Roentgenogram showed a slight clouding of the joint.

Day 18 Knee showed 135 degrees' limitation of extension, with large amount of swelling, especially in the upper pouches of the joint. Culture from joint negative.

Day 24 Joint showed marked swelling extending down the lower part of the leg, with nodule formation, and limitation of 120 degrees' extension. Culture showed a small growth. Roentgenogram showed a marked irregularity of the joint line, with destruction of the joint surfaces and a thinning of the lower end of the femur.

Day 31 (autopsy) Culture showed a negative growth. Roentgenogram showed the same joint changes as were seen in the last roentgenogram, with less clouding about the joint.

When the skin was removed there was a limitation of about 120 degrees of full extension, with nodule formation down the inner side of the lower part of the leg. Some gentian was found in the popliteal space. There was a roughening on the under surface of the patella and on the lower surface of the femur. A small amount of pus was present on the joint. The cartilages were pretty well destroyed. All the crucial ligaments were thinned but not destroyed. There was a great deal of fibrous tissue in the posterior portion of the joint which seemed to limit full extension, with a thickening of the capsule.

Microscopic examination of a section from the right knee did not show the tibia clearly, but the changes in the femur were plain. There was an erosion of all the cartilage, with the exception of a few islands. The cartilage had been replaced by fibrous tissue. There was a large abscess containing islands of cartilage which extended through the epiphyseal line of the femur well encapsulated. There was a good deal of fibrous tissue through the joint. Pus was found through the muscles. The inflammatory process looked like one which was becoming progressively more acute. The fibrous tissue in places had supplanted the bone marrow.

RABBIT 23—Sex, male, weight, 3 pounds (1.4 Kg.), age, 3 1/2 months. Injection of right knee, April 16, 1926, with 0.1 cc. of a twenty-four-hour broth culture of *Staphylococcus aureus*.

Day 1 Right knee showed a fair amount of swelling, with increase in local heat and limitation of last 15 degrees of extension. Culture from joint negative. Injection of 1 cc. of 0.25 per cent dextrose gentian violet.

Day 3 Right knee showed moderate amount of swelling, with limitation of 75 degrees of extension. Culture from joint positive. Injection of 1 cc. of dextrose gentian violet.

Day 4 Right knee showed more marked swelling, with 110 degrees' limitation of extension and increase in local heat. Culture from joint negative. Injection of 1 cc. of 0.25 per cent dextrose gentian.

Day 6 Swelling of right knee was even more marked, with 120 degrees' limitation of motion and increase in local heat. Culture from joint negative.

Day 7 Right knee showed same swelling and motion. Roentgenogram showed a clouding of the joint with a slight fuzziness of the posterior portion of the tibia.

Day 24 Right knee showed 135 degrees' limitation of extension with a large amount of swelling which was of the nodular type. Roentgenogram showed a marked clouding of the joint with a destruction of the joint line and a thinning of the lower femur.

Day 41 Right knee showed same swelling and motion Roentgenogram showed a marked destruction of the joint with a thinning of the condyles of the femur and a thickening of the upper end of the tibia, and a clouding of the whole joint

Day 53 (autopsy) Culture from right knee negative

Gentian or pus was not discovered in the surrounding tissues When the joint was opened the large amount of fibrous reaction in the joint was most marked All the cartilages were destroyed with a roughening of all bony surfaces The fibrous tissue had completely filled the joint Pus or gentian were not found in the joint

Microscopic examination could not be performed because the specimens were lost

RABBIT 10—Sex, male, weight, 3 pounds, 8 ounces (1.6 Kg), age, 4 months Injection of right knee with 0.1 cc of a twenty-four hour broth culture of *Staphylococcus aureus* on Jan 16, 1926

Day 1 The right knee showed a slight amount of swelling, with increase in local heat, tenderness and limitation of the last 15 degrees of extension The rabbit looked toxic

Day 2 Right knee was more swollen, with more local heat increase and limit to last 30 degrees' extension Roentgenogram showed a slight clouding about the knee joint Culture from joint showed moderate growth Injection of 1 cc of 0.25 per cent aqueous gentian

Day 3 Knee joint showed a fair amount of swelling, with limit of 90 degrees' extension and more increase of local heat Rabbit had lost weight Weight, 3 pounds, 2 ounces (1.4 Kg) Culture from joint positive Aspirated cloudy bloody fluid

Day 4 Knee was same as on third day Injection of 1 cc 0.25 per cent aqueous gentian

Day 6 The right knee showed more swelling, this being marked in the suprapatellar pouches, with same amount of motion Culture positive from joint Aspirated thick purulent material which was slightly purple

Day 14 Knee was more swollen, with limit of 110 degrees' full extension with fluctuant swelling up into pouches above the knee Weight, 2 pounds, 14 ounces (1.2 Kg) Culture from joint showed good growth of organism

Day 33 There was 120 degrees' limit to motion, with moderate amount of swelling Culture from joint positive

Day 41 Right knee showed same swelling and motion with more crepitation about the joint Roentgenogram showed a marked destruction about the joint with a thinning of the condyles of the femur and thickening of the upper end of the tibia, with evidence of destruction on the under surface of the patella Some shadows were also seen behind the joint

Day 72 A moderate amount of swelling was present about the joint, with nodule formation and a limit of 120 degrees of extension Culture showed a good growth of the organism Aspiration of thick grumous material

Day 76 The right knee showed the same nodular swelling, especially on the inner side of the joint, with a thickening of the upper tibia

Autopsy Culture from right knee positive

There was a marked swelling about the right knee in large nodular masses, which contained creamy yellow material, especially on the inner upper aspect of the lower part of the leg Extension was not possible beyond 120 degrees When the joint was opened a thinner caseous material was encountered There was a large amount of fibrous tissue throughout the joint with a lateral disloca-

Day 31 (autopsy) Culture from right knee negative Roentgenogram showed same irregularity and destruction, with more thinning of the lower end of the femur

There were many nodules about the joint with a swelling of the joint Gentian was found in the foreleg and about the joint When the joint was opened a large amount of purplish purulent material was found The crucial ligaments and semilunar cartilages were thinned but not altogether destroyed There was only a slight roughening of the cartilage on the under surface of the patella and condyles of the femur The impression was that not as much reaction had occurred in this joint as in some of the others, with the same amount of swelling and limitation of motion

Microscopic examination of a section from the right knee revealed a marked reaction in the joint All the joint surfaces were irregular, with an erosion of joint cartilage, only a small amount being left intact in the anterior part of the femur which had fibrous tissue growing into it A large amount of pus and fibrous tissue was present in the joint The bone was eroded in spots There was one place where the bone and cartilage have sequestered off A large abscess was seen in the upper diaphysis of the tibia There were several abscesses in the popliteal space and pus under the periosteum in the anterior part of the femur The fibrous tissue was supplanting the bone marrow in places The inflammatory process was subsiding

Rabbit 24—Sex, male, weight, 3 pounds, 8 ounces (1.6 Kg), age, 3 1/3 months Injection of right knee, April 19, 1926, with 0.1 cc of a twenty-four-hour broth culture of *Staphylococcus aureus*

Day 1 Right knee showed a slight amount of swelling, with limitation of last 15 degrees of extension and increase in local heat Culture from joint positive Injection of 1 cc of 0.5 per cent olive oil gentian violet

Day 2 Right knee showed same amount of swelling, with 20 degrees' limitation of extension and increase in local heat Culture from joint positive Injection of 1 cc of 0.5 per cent olive oil gentian

Day 3 Right knee showed a much more marked reaction, with more swelling extending down lower part of leg into ankle and foot, with much more local heat and a limitation of 90 degrees of full extension Culture from joint showed a small growth Injection of 1 cc of 0.5 per cent gentian in olive oil

Day 4 Right knee about the same, with perhaps 100 degrees' limitation of motion Roentgenogram showed a clouding of the joint

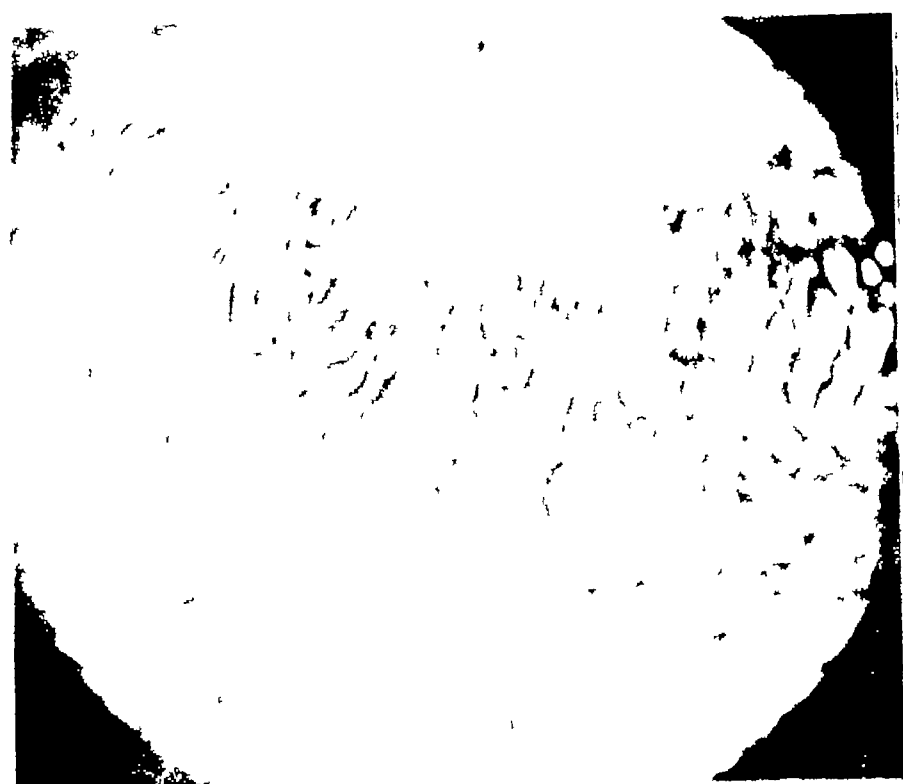
Day 9 Right knee showed less swelling which now extended only to ankle and not into foot, with 90 degrees' limitation of extension Culture from joint showed small growth

Day 15 Right knee showed perhaps less swelling down the lower part of the leg, but the same about the knee, with limitation of 75 degrees' extension Culture from joint did not show growth

Day 21 Right knee showed the same swelling, with 70 degrees' limitation to extension Culture showed a small growth after forty-eight hours Roentgenogram showed a slight haziness about the joint, with some irregularity and thickening of the lower femur

Day 28 (autopsy) Culture from joint negative Roentgenogram showed same picture as last described, with slightly less irregularity

Before the skin was removed there was about 75 degrees' limitation of motion, with some grating and lateral mobility in the joint Pus was present in gentian tinted nodules down the lower part of the leg There was thin mucoid pus in the joint, with small bodies suggesting rice bodies The liga-



18 and 21) Further, it was pointed out that in the fifty cases undergoing spontaneous remission these areas of hyperinvolution became reinvolved in subsequent exacerbations of the morbid process, hypertrophy and hyperplasia. This was to be expected in view of the fact that they were a portion of the parenchyma. Since the clinical tumors in this group of thirty-seven cases presented the microscopic appearance identical with that of the involutinal bodies or areas of hyperinvolution, since they had become involved with the remainder of the parenchyma in the present exacerbation, and since numerous remissions and exacerbations had occurred in the clinical course of the disease process



Fig 24—Higher power magnification of figure 23 showing in detail the typical disintegration toward the center of the localized area of hypertrophy and hyperplasia. This results, as is plainly seen, in a diminution of the actual number and size of the functioning parenchyma with a resultant substitution by fibrous connective tissue. These changes as shown are regressive involutinal changes of a degenerative nature, the opposite of the aggressive or regenerative changes characteristic of a true benign neoplasm. Reduced from a magnification of  $\times 57$ .

in these cases, it would seem highly probable that the tumors or nodules in these cases were the result of the long continued hyperthyroidism, and that they did not play a part in the production of the present clinical signs and symptoms anymore than did any other portion of the parenchyma.

ments looked fairly normal with some roughening of the cartilage. The semilunars looked normal. A peculiar bony nodular swelling was observed on the condyles of the femur.

Microscopic examination of a section from the right knee showed a fair amount of reaction. There was an irregularity of the cartilage mainly of the opposing surfaces. A fair amount of fibrous tissue was found in the joint, with pus and fibrin. The largest part of the cartilage was replaced by fibrous tissue. Fragments of bone and cartilage were present in the joint. There was fibrous tissue in the joint attached to cartilage. The anterior part of the tunic was well preserved with cartilage. A sesamoid bone was present in the popliteal space. There was no abscess formation. In places the bone marrow had been supplanted by fibrous tissue. The inflammatory process was in the subacute stage.

RABBIT 25—Sex, male, weight, 3 pounds, 2 ounces (1.45 Kg), age, 3½ months. Injection of right knee with 0.1 cc of a twenty-four-hour broth culture of *Staphylococcus aureus* on April 19, 1926.

Day 1. There was a slight amount of swelling in the joint, with increase in local heat and restriction of 25 degrees' extension. Culture from joint positive. Injection of 1 cc of 0.5 per cent olive oil gentian violet.

Day 2. Right knee showed the same reaction. Culture from joint positive. Injection of 1 cc of 0.5 per cent olive oil gentian.

Day 3. Right knee showed a limitation of 75 degrees' extension, with same amount of swelling and increase in local heat. Gentian recovered in aspiration. Culture from joint showed a small growth. Injection of 1 cc of 0.5 per cent olive oil gentian.

Day 4. There was a more marked reaction with 110 degrees' limitation of extension and the same amount of swelling. Roentgenogram showed a clouding of the joint.

Day 9. There was an increase of the motion to 45 degrees' limitation of extension, with probably more marked swelling and less local heat. No gentian now in the aspiration. Culture from joint showed small colonies of the *Staphylococcus aureus*.

Day 15. The same amount of swelling was filling the outer pouches of the knee, and extension was limited 60 degrees. Culture from joint showed few small colonies.

Day 21. There was less swelling with same motion as last noted. Culture showed one small colony in forty-eight hours.

Day 28 (autopsy). Culture from knee negative. Roentgenogram showed a marked haziness about the joint, with an irregularity of the upper tibia and the lower femur.

There was a large amount of purplish tinged pus in the tissues of the lower part of the leg. The joint capsule was distended with a light mucoid material. There was a limitation of the full extension of 60 degrees. There was a definite grating of the patella on the femur. A moderate amount of swelling was present about the joint. The joint was not opened.

Microscopic examination of a section from the right knee disclosed erosion of the cartilage in several places. The cartilage on the tibia had fibrous tissue growing beneath, and in places along the femur cartilage was growing out into the fibrous tissue. A small amount of pus and fibrin was present in the joint with a fair amount of fibrous tissue. There were thickened synovial tags. The semilunar cartilages were intact. There was a replacing of the bone marrow with fibrous tissue. The inflammatory reaction was still in the acute stage.

# THE TRANSFUSING OF UNMODIFIED BLOOD

IV EXPERIENCE IN NEARLY TWO THOUSAND, FIVE HUNDRED  
CASES CHANGES IN APPARATUS \*

OSBORNE ALLEN BRINES, M.D

Pathologist to Receiving, the Jefferson Clinic and Eloise Hospitals

DETROIT

The progress and results of blood transfusion at this clinic, first with the Unger<sup>1</sup> apparatus and then with my modification<sup>2</sup> of the Unger apparatus, have previously been discussed in part by Dr Blain and me<sup>3</sup> With these two types of apparatus, which were somewhat similar, nearly 2,500 transfusions of unmodified blood have been performed The method has proved satisfactory and leaves little to be desired The method provides for a continuous flow of blood from the donor to the recipient with scarcely any clotting, because stagnation is eliminated The maximum of speed is acquired, the time necessary for the actual transfusion of 500 cc being about five minutes Many of the transfusions have required even less time, and it has never been observed that the blood was given too rapidly Foreign material is not introduced during the transfusion, with the exception of 3 or 4 cc of saline before any blood passes through the apparatus, and this is for the purpose of demonstrating the correct position of the needle in the recipient's vein

There have not been any deaths directly attributable to transfusion in the series Transfusion may have been a contributing factor in the cause of death in three cases of nephritis My experience, naturally, added to the observations of others, leads me to suspect that nephritis might constitute a contraindication to transfusion The only other contraindications are pulmonary edema and a damaged myocardium Although I have never observed unfavorable consequences following transfusion in cases of heart lesions, I would advise caution

The criteria of a post-transfusion reaction should include, in addition to a mere elevation of temperature, some definite subjective or objective symptoms, such as a chill, pain, dyspnea, urticaria, hemoglobinuria and jaundice

\*From the Jefferson Clinic and Diagnostic Hospital

- 1 Brines, Osborne A The Transfusing of Unmodified Blood Arch Surg 7 306 (Sept) 1923
- 2 Brines, Osborne A The Transfusing of Unmodified Blood II The Technique in 1000 Cases, Arch Surg 12 124 (Jan) 1926
- 3 Blain, Alexander W, and Brines, Osborne A The Transfusing of Unmodified Blood III The Clinical Aspect of 1000 Cases, Arch Surg 12 140 (Jan) 1926

RABBIT 26—Sex, male, weight, 3 pounds, 4 ounces (1.5 Kg), age, 3½ months  
Injection of right knee with 0.1 cc of a twenty-four-hour broth culture of *Staphylococcus aureus* on April 20, 1926

Day 1 Right knee showed a slight swelling, with limitation of last 10 degrees of motion and increase in local heat. Culture from joint positive.  
Injection of 1 cc of 0.5 per cent olive oil gentian violet

Day 2 A marked swelling of the knee extended down the ankle to the foot, with a limitation of 90 degrees of full extension, and an increase in local heat. Culture from joint positive. Injection of 1 cc of 0.5 per cent olive oil gentian violet

Day 3 Knee showed limitation of 110 degrees' full extension with same swelling down leg to ankle and foot. Culture from joint positive. Injection of 1 cc of 0.5 per cent olive oil gentian. Roentgenogram showed a slight clouding of the joint

Day 8 There was more marked swelling of the whole knee, lower part of the leg and foot with motion limited 100 degrees. Culture from joint positive

Day 14 There was a more nodular swelling around the knee which extended down the foreleg to the ankle. At the ankle there was an open draining sinus from which gentian tinted pus could be expressed. A culture from this showed the same organisms. The motion at the knee and ankle was limited 90 degrees. Culture from knee joint showed positive growth

Day 20 Right knee showed the same nodular swelling, with a limitation of extension of 100 degrees. The swelling down the leg was not as marked. The motion in the ankle was now limited only 30 degrees. There was a scab over the sinus at the ankle. Culture from knee showed one colony after forty-eight hours. Roentgenogram showed a haziness about the joint surface, with an irregularity of the upper tibia and lower femur, with a thickened nodule on the femur

Day 27 (autopsy) Culture from knee was negative. Roentgenogram showed same condition as on twentieth day

A rather large nodular swelling was seen about the joint and a distention of the joint capsule proper. A good deal of caseous looking gentian tinted pus was present in the popliteal space and around the joint, also down the lower part of the leg. There was a definite increase in the mobility of the joint with a grating on motion. The joint was not opened

Microscopic examination of a section from the right knee revealed a large amount of reaction and destruction in the joint. There was a marked irregularity of the joint surfaces. All the cartilage was eroded except that on the anterior surface of the femur. Fissures were present in the cartilage on the tibia. A large amount of fibrous tissue and pus was found in the joint. There were abscesses anterior to the head of the tibia and in the popliteal space. Thickened synovial membrane in the popliteal area. There was a small sesamoid bone anterior to the femur, which might have been the patella but was not altogether typical of this. Thickened crucial ligaments were present. In places, the bone marrow had been supplanted by fibrous tissue. The inflammatory process was fairly acute

RABBIT 27—Sex, female, weight, 3 pounds, 8 ounces (1.6 Kg), age, 3½ months. Injection of right knee with 0.1 cc of a twenty-four-hour broth culture of *Staphylococcus aureus* on June 3, 1926

Day 1 Right knee showed a fair amount of swelling and increase in local heat, with limitation of 10 degrees' extension. There was also a swelling of the glands in the right groin. Culture from joint positive. Injection of 1 cc of 0.5 per cent dextrose gentian violet



In nearly 2,500 cases in which transfusion was used, only three patients had severe post-transfusion reactions. All were purely anaphylactic in type and occurred with sudden onset immediately following the transfusion. One reaction was extremely severe and the other two moderately severe.

One of the less severe reactions consisted of a convulsion followed by coma and accompanied by an increase in pulse rate and a decrease in the volume of the radial pulse, shallow and slowed respirations and cyanosis, all of which lasted about thirty minutes and were immediately followed by complete recovery.

The most severe reaction consisted of a convulsion and then coma, cyanosis and shallow respiration, the respiratory rate dropping to 2 or 3 a minute, and complete disappearance of the radial pulse and inaudible heart sounds. This state lasted about half an hour, after which the pulse and respiration became satisfactory, the patient reacted to his surroundings at the end of an hour, but remained more or less delirious for several hours.

The third reaction occurred in one of the cases of nephritis mentioned, and the initial symptom was a sudden onset of severe generalized abdominal pain which, after about ten minutes, shifted to the lumbar region. The pain was relieved by the administration of morphine sulfate,  $\frac{1}{2}$  grain (0.03 Gm.), but a severe chill accompanied by an elevation in temperature of  $4^{\circ}\text{F}$  followed. The reaction in this form was intermittent and lasted with diminishing severity for about thirty-six hours. Uremic symptoms became conspicuous and death occurred in five days. A careful recheck of grouping and crossagglutination failed to reveal the slightest incompatibility in any of these three cases.

Crossagglutination as a routine procedure was abandoned as unnecessary and superfluous in the laboratory of the Jefferson Clinic four years ago, when we began to use group IV (Moss) agglutinating serum in addition to the usual group II and group III serums. By this means, we are able to detect deterioration of either group II or group III serum. Errors in blood grouping are usually not due to poor laboratory technique but to a sudden reduction in titer of the known serums. It is a well known fact that agglutinating serum may possess sufficient titer today but tomorrow may be absolutely useless. In some laboratories where several days and even weeks may elapse between requests for blood grouping, the serums employed are not reliable without this additional safeguard, which depends on the fact that if there is agglutination with group IV serum, there must be agglutination with either group II or group III serum or both. When agglutination is produced with group IV serum alone, one of the other serums must be impotent, and an investigation can be made. The most common error in grouping, and the only one that I have personally witnessed, is placing a group II

Day 2 There was more swelling, with an increase in local heat and limitation of last 45 degrees of extension Gentian was aspirated from the joint Culture from joint negative Injection of 1 cc of 0.5 per cent dextrose gentian

Day 3 Joint showed a slight decrease in the swelling and local heat, and 30 degrees' limitation of motion Crepitation was present in the suprapatellar pouches Gentian aspirated Culture from joint negative

Day 4 Knee showed same amount of swelling, with crepitation and 45 degrees' limit to full motion Culture from joint negative

Day 9 Joint showed same amount of swelling, with no increase in local heat and 100 degrees' limitation of full extension Culture from joint negative Roentgenogram showed a slight haziness about the joint

Day 13 Knee showed slightly less swelling and 90 degrees' limitation of extension Small amount of caseous gentian tinted tissue aspirated Culture from joint negative

Day 18 Joint showed a moderate amount of swelling, with an increase in the size of band running from the joint up to the groin There was 90 degrees' limit to full extension Gentian aspirated Culture from joint negative

Day 68 The knee showed about the same swelling and a limit of extension of 90 degrees There was some crepitation of the tissues and a nodule in the upper inner pouch about the joint

Day 156 The right knee could not be extended beyond 90 degrees There was no swelling The rabbit looked sick and emaciated There was an extensive ulceration over the right buttock extending up to the flank

Day 160 The rabbit died of malnutrition and weakness Autopsy was not performed

RABBIT 28—Sex, male, weight, 3 pounds, 13 ounces (1.7 Kg), age, 4 months Injection of right knee with 0.1 cc of a twenty-four-hour broth culture of *Staphylococcus aureus* on June 3, 1926

Day 1 Right knee showed a slight amount of swelling, with increase in local heat and 5 degrees' limitation of extension Culture from joint positive Injection of 1 cc of 0.5 per cent dextrose gentian

Day 2 Right knee showed a marked amount of swelling which had extended down the whole lower part of the leg into the foot, with 75 degrees' limitation of extension Culture from joint positive Injection of 1 cc of 0.5 per cent dextrose gentian

Day 3 Joint showed about the same amount of swelling extending down the leg to the foot, with slightly less limitation of extension to 60 degrees and an increase in local heat Culture from joint positive Injection of 1 cc of 0.5 per cent dextrose gentian

Day 4 Joint showed the same amount of swelling with 80 degrees' limitation of extension Gentian aspirated from joint Culture from joint negative

Day 9 Joint showed essentially the same swelling with 90 degrees' limit to full extension Gentian aspirated Culture from joint negative Roentgenogram of joint did not show any changes

Day 13 Knee showed about the same swelling and motion Thin gentian aspirated Culture negative

Day 18 The right knee seemed much improved, with less swelling and 75 degrees' limit to extension Thin gentian aspirated Culture from joint negative

Day 50 The rabbit died of unknown cause Autopsy was not performed

RABBIT 29—Sex, male weight, 3 pounds, 5 ounces (1.55 Kg), age 3½ months Injection of right knee with 0.1 cc of a twenty-four-hour broth culture of *Staphylococcus aureus* on June 3, 1926

(Moss) individual in group IV, and probably the most important reason for this error is the use of old group III serum due to the difficulty or inconvenience experienced in securing group III serum because of the small number of group III individuals. The use of group IV serum is not an infallible check, but will practically eliminate all error, because it is unlikely that two of the agglutinating serums will deteriorate at the same time, besides, on account of the prevalence of group IV individuals, fresh group IV serum can be obtained frequently—every two or three days—and therefore can be regarded with the greatest confidence. The only error that cannot be guarded against by the use of group IV serum is that of mistaking a group I for a group II or a group III individual, the reason for this is that the cells of a group I individual are agglutinated by both groups II and III serum, and impotence of one or the other would not be detected by this method. The small number of group I individuals minimizes the importance of this danger, and the possibility of such a mistake argues for the more extensive use of universal donors. Since the introduction of group IV serum in the laboratory as a check on the potency of group II and group III serums, errors in grouping have not been made.

In my experience, incompatible blood was used in six transfusions. Four of these errors in grouping occurred in laboratories other than this one, and two occurred in the laboratory before I began to use group IV serum. No casualties resulted in four cases. In one of the other two, death was inevitable and was perhaps hastened by the transfusion. Suspicion regarding compatibility was aroused by the sudden cyanosis of the patient when about 200 cc of blood had been introduced. The other case was one of the three cases of nephritis mentioned before. The patient was moribund, and when about 100 cc of blood had been introduced, dyspnea was suddenly observed. The transfusion was stopped because of the belief that incompatible blood was being used. A severe reaction consisting of a chill and dyspnea occurred, and death followed in three days. In all six cases, group II blood was given to group IV patients. In one case, the error was a clerical one in reporting. In these two cases just described, one patient was comatose and the other was semiconscious, if the operator is reasonably careful and alert, it is only in this type of case that a fatality may follow the use of incompatible blood. The nervous reaction of these patients is too sluggish to detect or to betray the aura of a transfusion reaction, and before it becomes evident that the patient is not behaving normally, a sufficiently large quantity of blood to produce serious consequences has been given. It is likely that a patient who is fully conscious will inform the operator, who should always have in mind the possibility of using incompatible blood, of the first unusual or uncomfortable sensation, which is commonly lumbar or mediastinal pain or respiratory difficulty. Such a warning

Day 1 Right knee showed a slight amount of swelling, with increase in local heat, and about 5 degrees' limitation of full extension Culture from joint positive Injection of 1 cc of a 0.5 per cent dextrose gentian preparation An extravasation of this took place into the tissues on the inner side of the knee

Day 2 Knee showed a moderate amount of swelling, with 60 degrees' limitation of extension and marked increase in local heat Culture from joint positive Injection of 1 cc of 0.5 per cent dextrose gentian

Day 3 Right knee showed an increase of the same swelling up into the groin with marked crepitation of the tissues and 75 degrees' limitation of full extension Culture from joint showed a small growth Gentian aspirated Injection of 1 cc of 0.5 per cent dextrose gentian

Day 4 Right knee showed the same amount of swelling, which had now extended down into the lower part of the leg, with 90 degrees' limit to full extension Culture from joint negative Gentian aspirated

Day 9 Right knee showed slightly less swelling, with crepitation up into the thigh and 100 degrees' limit to full extension Cultures from joint negative Gentian aspirated Roentgenogram of the right knee did not show any changes in the joint This picture showed the same appearance of the joint as that taken before infection

Day 13 Right knee showed fair amount of swelling, with 110 degrees' limit to full extension, crepitus in the joint and a small ulceration below the knee Weight, 3 pounds, 7 ounces (1.6 Kg) Culture from joint negative Gentian aspirated

Day 18 The right knee showed a marked improvement, with only a small amount of swelling and 60 degrees' limit to full extension Culture negative Gentian aspirated

Day 21 (autopsy) Culture from right knee negative

There was more than 45 degrees' limit to full extension, with a fair amount of swelling A purple tinge was present all about the joint when it was opened An air space was found up in the groin The gentian was found down the outer side of the lower part of the leg, almost to the ankle When the joint was opened transversely, it was found to be filled with gentian Pus was not present in the joint Close examination of the ligaments and cartilage in the joint revealed no change The gentian was also in the popliteal tissues Limitation of motion could not be demonstrated after the joint was opened

Microscopic examination could not be performed because the specimens were lost

RABBIT 30—Sex, female, weight, 3 pounds, 4 ounces (1.5 Kg), age, 3½ months Injection of right knee with 0.1 cc. of a twenty-four-hour broth culture of *Staphylococcus aureus* on June 3, 1926

Day 1 Right knee showed a slight amount of swelling, with increase in local heat and 5 degrees of limitation of extension Culture from joint showed good growth Injection of 1 cc of 0.5 per cent dextrose gentian

Day 2 Knee showed increase in swelling, with increase in amount of local heat and 20 degrees' limit to extension Culture from joint negative Aspiration showed gentian Injection of 1 cc of 0.5 per cent dextrose gentian

Day 3 Joint showed slight increase in local heat, with less swelling and 30 degrees' limit to extension Culture from joint negative Gentian aspirated

Day 4 Joint showed 45 degrees' limit to extension and same amount of swelling, with crepitation up into the groin Culture did not show growth Gentian aspirated

symptoms will usually occur before 40 cc of blood has been given, and if the transfusion is discontinued promptly, nothing more serious than a mild or moderately severe reaction will result.

There is one type of post-transfusion reaction which is seldom mentioned and has received little attention, but which occurs with mild symptoms in a small percentage of cases, that is the delayed reaction. I was slow in appreciating the existence of such a type of reaction, because as a rule I did not observe the occurrence myself, and when I was occasionally told that a patient who had received a transfusion in the morning had a mild or moderately severe chill that night or the next day, lasting sometimes for an hour or more, I was inclined to consider this a mysterious affair unrelated to the transfusion, because I was sure that if a reaction did not occur within two hours, none would occur. The delayed reaction is now recognized but a possible explanation for such a phenomenon cannot be suggested.

As far as I know, embolism has never been produced during a transfusion given by my associates or me. I have never seen a case of air embolism, but I recognize that there is danger of such an occurrence, and I never inject more than a few very small bubbles of air.

In only two cases in this series did the attempt to perform a transfusion fail because of inability to introduce the needle into the patient's vein. The first case was that of an infant, and this incident has been described in a previous article.<sup>2</sup> The second unsuccessful attempt was made in the case of an obese woman who had received two transfusions within the preceding two or three weeks. Both arms had been used, and on each side an incision had been made and the vein exposed but not transected or ligated. The third transfusion for this patient, who was a poor surgical risk, was attempted in the operating room at the end of an abdominal operation. Incisions in the arms were necessary, but a mistake was made in that the new incisions were parallel to the old ones, instead of being started where the previous ones ended. The veins which had been entered before were tried this time, and in each arm the vein parted at the old site of venous puncture when the pressure of the needle was exerted, and the proximal end of the vein could not be picked up and no other veins could be readily found. Before another location could be selected, the patient died. The technic was admittedly faulty, and a different line of attack would be employed in a similar case in the future. The use of universal donors is becoming more popular continually. One feels safer and less apprehensive of undesirable sequelae when the donor is in group IV. The records show that the smallest percentage of post-transfusion reactions has occurred when the donor has been in group IV, regardless of whether the recipient is in group I, II, III or IV, and the largest percentage of reactions has occurred when both donor

Day 9 Right knee showed same swelling, with 75 degrees' limit to extension and little crepitus Culture from joint was negative, gentian aspirated Roentgenogram did not show changes

Day 13 Joint showed same swelling, with less limitation of extension, this being now 40 degrees The rabbit showed a marked loss of weight Weight, 2 pounds, 11 ounces (1.2 Kg) Culture from joint negative Gentian aspirated

Day 18 Right knee was almost normal, with just a little limitation of extension, about 5 degrees, and the slightest amount of swelling Culture negative Gentian aspirated

Day 55 There was no limitation of motion, with no swelling A small scab was seen on front surface of knee beneath which a little pus was found

Day 68 Knee joint showed a small amount of swelling with about 10 degrees' limitation to full extension

Day 156 The right knee showed a distinct lateral dislocation with apparent evidence of the crucial ligaments being relaxed There was about 70 degrees' external rotation with 30 degrees of abduction and 45 degrees' limitation to full extension Swelling was not present

Day 170 The knee showed a limit of 90 degrees to full extension, with the same lateral displacement Weight, 4 pounds, 8 ounces (2 Kg)

Autopsy The joint was opened transversely across the patellar tendon Pus and gentian were not found in the joint There was a marked erosion of all the cartilage over the condyles of the femur, with small islands of cartilage remaining Small bits of cartilage were free in the joint There was also a distinct roughening of the bone The crucial ligaments were thin and extremely relaxed, and allowed the lateral mobility of the joint The semilunar cartilages were thin and irregular in contour There was a slight fibrous reaction on the sides of the joint

Microscopic examination of a section from the right knee revealed a marked thinning of the femur and thickening of the head of the tibia There was an irregularity of the cartilage which was destroyed in spots along the joint surfaces A marked fibrous tissue reaction was seen in the joint, in which there were clumps of cartilage cells In spots the bone was eroded The semilunar cartilages were present and intact The crucial ligaments were much thinner than normal A sesamoid bone was present in the popliteal space There was a thickening of synovial membrane Pus was not present Slight leukocytic infiltration of the muscle had occurred The surface of the bone gave the impression of one which has healed Small villous processes were present in the joint, which had proliferated from the synovial membrane There was a proliferation of cartilage Little acute inflammation was seen in this joint

and recipient have been in group II. The work of Guthrie and Huck<sup>1</sup> has shown the possibility of a number of groups in addition to the four which are usually considered, but it is doubtful whether it will ever be necessary to give all of these groups practical consideration. However, in the work in our laboratory, we have long recognized two subdivisions of group II, and I believe that they are of practical importance. A study of different group II individuals when it was observed that in some cases agglutination by group III and group IV serum occurred slowly and incompletely. For lack of a better classification, we began to use the terms "slow twos" and "fast twos." The discovery that the percentage of post-transfusion reactions was nearly twice as great when the donor and recipient were in group II as when any other combination was used leads me to believe that the recognition of "strong and weak twos" were of practical importance. At the present time, we are collecting data on the comparative results produced in the form of post-transfusion reactions when both donor and recipient belong to the same subdivision of group II and when the subgroups are mixed. We advocate the preference of group IV or universal donors in all transfusions when no more than 750 cc of blood is to be transfused, especially in selecting professional and semiprofessional donors for group II recipients, because of the existence of subdivisions of group II, which are of practical importance and which increase the incidence of reactions. Besides, as I have pointed out, the only real practical error which might occur in blood grouping by the method employed in our laboratory is when one is dealing with group I individuals and the least possibility of error when one is dealing with group IV individuals. This would argue well for the use of group IV donors with patients of groups I and II at least, group III is such a small group that a group III donor is seldom needed, and when needed is seldom found. I therefore feel justified in recommending the preference for group IV donors in all transfusions when practical.

Two questions frequently asked are whether donating blood is harmful to the donor and whether the group of an individual ever changes. I cannot state positively that the repeated withdrawing of blood in 500 cc quantities is harmful. I have not observed any ill effects. Three of our donors have served between eighty and 150 times over a period of five years, and they are all in excellent health and as far as I know, specimens of fine physique. Some donors cannot

<sup>1</sup> Guthrie, C G and Huck, J G. Existence of More than Four Isoagglutinin Groups in Human Blood. Bull Johns Hopkins Hosp 32 37 (Feb) 1923 34 80 (March) 1923 34 128 (April) 1923

# EXTRAPLEURAL THORACOPLASTY A MUSCLE SPLITTING OPERATION \*

JEROME R HEAD, M D  
CHICAGO

The Wilms-Sauerbruch operation of extrapleural thoracoplasty is performed as a routine through a single paravertebral incision. The incision extends from the upper border of the trapezius muscle to a point over the eleventh rib, and is carried down through the layers of muscle to the level of the ribs at the outer border of the erector spinae group.

This incision necessitates transverse section of the trapezius, rhomboids and latissimus dorsi, and is consequently bloody and traumatizing. It is certain that it favors postoperative shock and infection of the wound, complications which, as Archibald has recently brought out, account for most of the direct operative mortality.

Furthermore, when the operation is performed in stages, if even a slight infection occurs after the first or second stage, it is necessary to prolong the interval between operations, frequently to such an extent that the resected ribs regenerate and the final collapse is compromised.

It seemed to me that these drawbacks could be obviated and the function of the arm and shoulder better preserved if the operation were performed through separate incisions and the ribs approached by splitting rather than by transecting the broad muscles of the shoulder girdle.

To meet these requirements, the following muscle splitting operation in three stages has been devised.

The first incision begins over the eleventh rib just lateral to the spine and runs upward and outward over the angle of the scapula. The skin and subcutaneous tissues are freed from the latissimus dorsi for a short distance on each side of the incision, and this muscle is split in the direction of its fibers. The loose areolar tissue binding the muscle to the ribs and the intercostal structures can be freed easily by the finger, and, this having been done, adjustment of the retraction gives easy access to the posterior segments of the eighth, ninth, tenth and eleventh ribs.

The second incision is in the line of the usual paravertebral one and extends from the spine of the scapula to the level of the eighth rib. Small flaps of skin and subcutaneous tissues are dissected up from the trapezius, and the muscle is split in the line of its fibers. The trapezius is freed on its under surface, and the rhomboid is thus brought into view. This muscle is similarly split and freed from the ribs and under-

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\*From the Surgical Service of the Research and Educational Hospitals of the Medical School of the University of Illinois.



give blood as frequently as others without becoming anemic, but the transfusions apparently do not have any permanent ill effects. In our experience or under our observation the group of an individual has never changed. All apparent instances were found on investigation to have been due to an error in grouping.

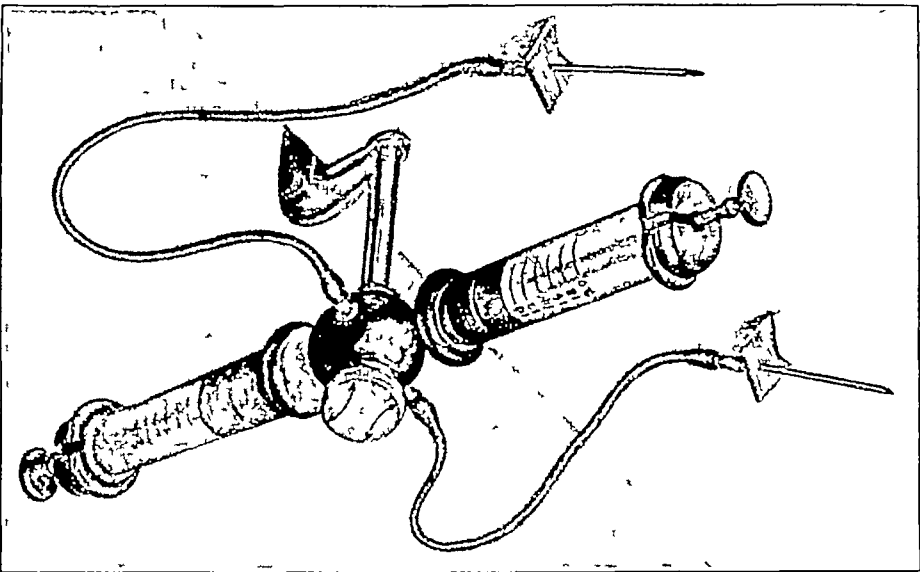


Fig 1—The apparatus used in blood transfusions. The arrows indicate the connections with the circulations of the donor and the recipient

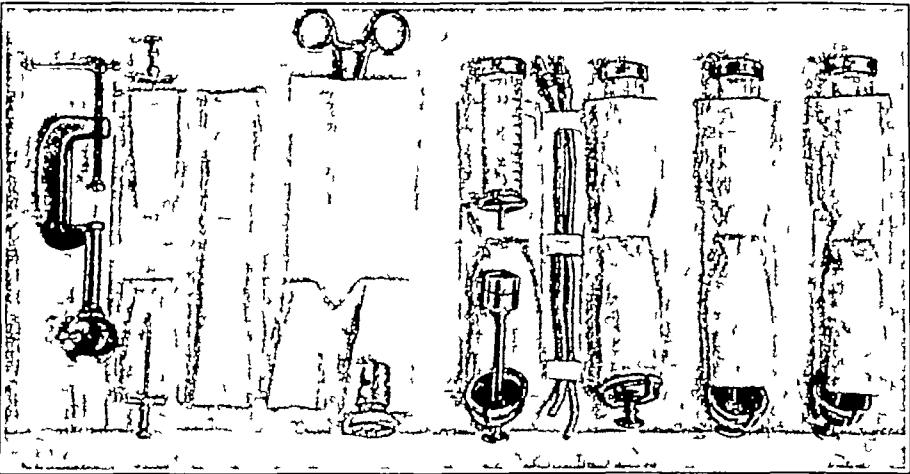
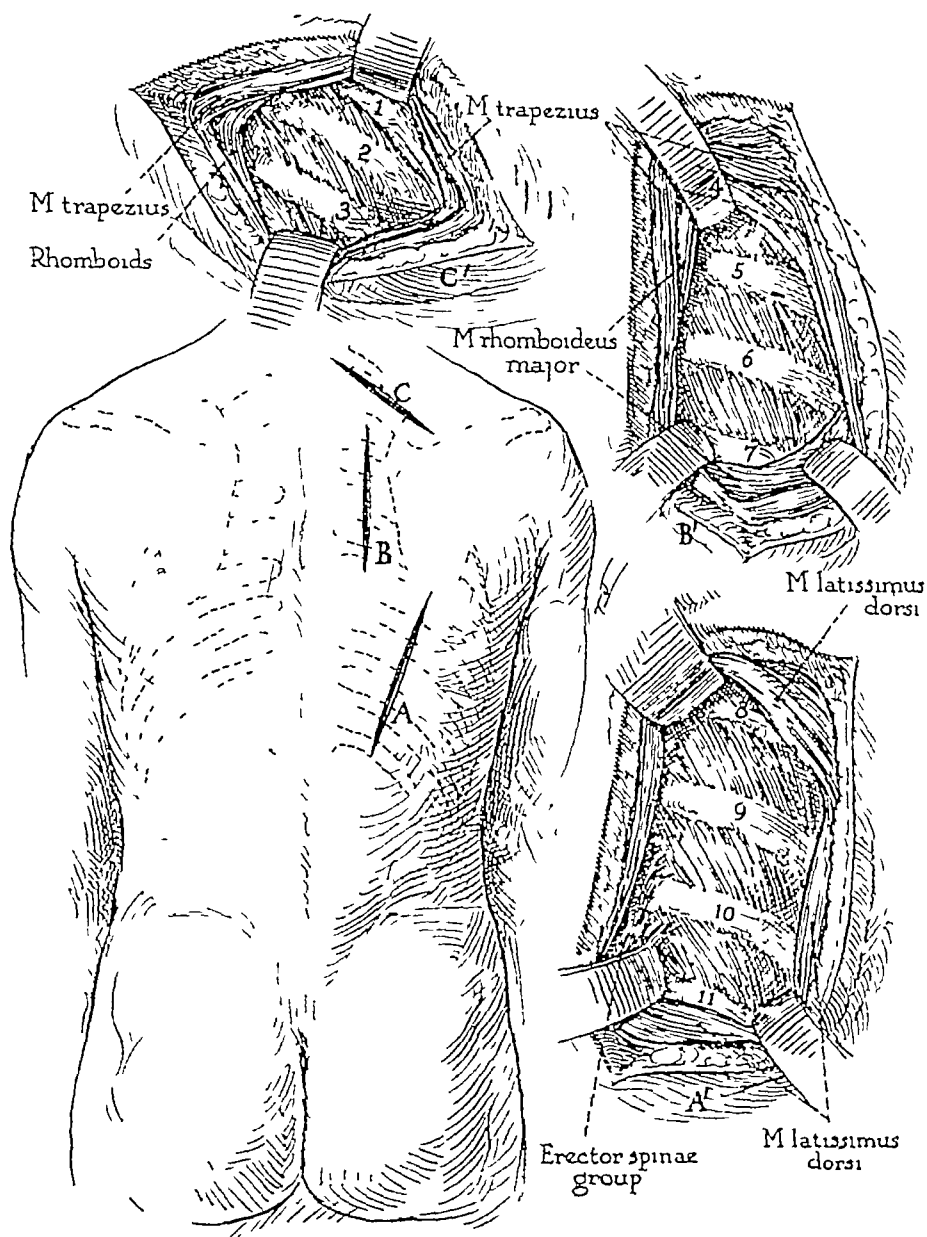


Fig 2—Sections of the apparatus in place in their respective compartments in the canvas roll designed for that purpose

The apparatus which has been used at the Jefferson Clinic and Diagnostic Hospital for the last three years up to a short time ago was a modification described in 1926.<sup>2</sup> This apparatus possessed several minor disadvantages, and we have looked over carefully

lying tissues Adjustment of the retraction gives easy access to the desired segments of the fourth, fifth, sixth and seventh ribs

The third incision is made in the line of the fibers of the trapezius and extends from the second dorsal spine to the middle of the spine of the scapula, or, in case there has not been infection in the second



A muscle splitting operation in three stages for extrapleural thoracoplasty

incision, it may be merely extended upward as has heretofore been the practice Flaps having been raised, the trapezius and rhomboid muscles are split and freed on their under surfaces Then proper adjustment of the retraction affords access to the posterior segments of the first, second and third ribs

the several apparatus placed on the market in the last two years hoping to find one more suitable. All were rejected, however, because of the principle involved or because we believed that our apparatus was more simple, more fool-proof and more accurate. We were not satisfied with any apparatus presented. With these imperfections and undesirable features of the equipment in mind, yet not wishing to make any radical changes or to deviate from the principle involved in the apparatus with which we had performed over 2,000 transfusions, our present apparatus was designed (manufactured by the J. F. Hartz Company, Detroit), the accompanying illustrations of which, I believe, are self-explanatory.

This apparatus possesses the following advantages

Foreign substance is not mixed with the blood, and the blood is not modified in any way

The amount of blood can be accurately measured

The apparatus is small and light and consists of only two parts

Lubrication of moving parts or paraffin coating is unnecessary

Veins are entered by needles

A canvas roll with a separate compartment for every piece of the equipment in which the apparatus can be wrapped immediately after cleaning and autoclaved and in which everything will remain sterile is part of the equipment

By means of arrows, only a glance is necessary to determine whether the operator's syringe communicates with the circulation of the donor or recipient, and thereby is eliminated the possibility of taking blood from or injecting it into the wrong person

By means of two syringes working opposite each other and always connected with the opposite side arm of the apparatus, it is possible to provide a continuous stream of blood from the donor to the recipient and thereby to reduce the possibility of clotting to a minimum, because stagnation will not occur in the apparatus

The donor, or recipient, may be placed on either side of the apparatus

The actual transfusion can be performed in less than five minutes

The blood is not unduly agitated, cooled or exposed to the air

#### METHOD

The donor and recipient are placed in the supine position about 18 inches apart, with their heads in the same direction, their shoulders opposite each other and with a table or board between them in such a position that the elbows of both the donor and the recipient lie over the board at the edge nearest the foot of the table. The donor is placed on the operating table in the operating room, and the recipient is allowed to remain on the stretcher car. An arm board about 12 inches wide is then placed under the pad on the table and allowed to project 18 inches. The car is then brought up to touch the end of the board. In the patient's home, conditions of the operating room must be simulated by various makeshifts

The two patients on whom this operation has been performed were able to be out of bed the third day after the final stage, and could move the arm and shoulder on the affected side freely in all directions without pain

#### SUMMARY

1 The usual paravertebral incision for the operation of extrapleural thoracoplasty has two serious drawbacks

(a) The transverse section of the broad muscles of the back adds to the hemorrhage and trauma and is a factor in postoperative shock, infection and deformity

(b) When the operation is performed in stages, as is usual, infection in one incision necessitates increasing the interval between operations, frequently to such an extent that the resected ribs regenerate and the final collapse is compromised

2 These drawbacks can be obviated by performing the operation in three stages through separate incisions, and by splitting rather than transecting the broad muscles of the shoulder girdle

The arms are bared to the shoulders, and the skin is cleansed with soap and the usual skin antiseptics. Ordinary sterile precautions are observed. Half inch pure gum rubber tourniquets are used, and the pressure of the donor's tourniquet frequently must be varied during the transfusion to obtain the best flow. The patient's tourniquet is removed as soon as the needle is introduced into the vein. The operator stands between the donor and the recipient facing the head of the operating table, and his assistant stands across the board facing him. The operator clamps the apparatus to the side of the board nearest him.

All syringes, which are 20 cc Records, are rinsed with saline. One syringe is filled with saline, and the tip is inserted into the opening on the side nearest the assistant. The apparatus is tested with this saline to eliminate obstruction and to demonstrate to the satisfaction of the operator that the needle is properly placed well within the lumen of the recipient's vein. A small amount of saline is allowed to flow slowly into the recipient's circulation while the needle is being introduced into the donor's vein, and then the remaining saline is discarded. The most prominent veins on the arms of the donor and the recipient are selected, usually these are superficial veins on the ventral surface of the arm over the elbow joint, but frequently other veins of the forearm and occasionally the radial veins are preferable. In the case of the donor, a deeper seated, well anchored vein is to be preferred to the easily movable, readily collapsed, superficial vein. Needles are inserted "toward the heart" because it is easier to introduce needles placed in this direction. The slight advantage in placing the donor's needle "toward the hand" does not compensate for the added difficulties encountered.

The skin is pierced beside the vein first, and then the vein is entered with a separate, slow, purposeful movement. Do not "peck" or "jab" at a vein. It is best to have about two thirds of the length of the needle buried beneath the skin. Needles must be sharpened before each transfusion. This is imperative. Fairly long concave bevels are best. We "hollow-grind" our needles by use of a small motor-driven emery wheel which is supplied at small cost by all firms that sell laboratory supplies. A 15 gage needle is used for the recipient and a 13 gage needle for the donor. The rubber tubing should have thick, stiff walls, cut in 9 inch lengths and a lumen that is just large enough to admit the adaptors. When the needles are in position, the donor's syringe is first filled with blood from the donor, then the stopcock is reversed, and this blood is emptied into the recipient's circulation while the assistant fills his syringe with donor's blood. This procedure is repeated until a sufficient amount has been transferred.

In the majority of transfusions, 500 cc can be given with the same two syringes. Occasionally, they begin to stick before the transfusion is completed, and it is necessary to exchange them for fresh ones, more than one change is rarely necessary. No less than four syringes should constitute a set. A slight amount of "sticking" is sometimes encountered which lasts while two or three syringes are being taken, and which is eliminated if additional strength is exerted when the plunger is pulled or pushed.

Either or any other substance should not be used to prevent "sticking" of the plungers. Speed in filling and emptying syringes is important for the success of the transfusion.

# AN EXPERIMENT WITH BROTH CULTURES OF STAPHYLOCOCCUS AUREUS AND GENTIAN VIOLET \*

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Following the lines of experimentation of Churchman <sup>1</sup> in 1922, when he showed that a slight increase in temperature had a definite effect on the bacteriostatic power of gentian violet, and of Gatch, Trusler, and Owen <sup>2</sup> in 1925, when they showed that gentian violet in 4 per cent dextrose was less toxic for rabbits than aqueous gentian violet, experiments were performed in test tubes and on agar plates to correlate these facts

Twenty-four hour broth cultures of *Staphylococcus aureus* containing about 9 cc of fluid were used Gentian violet was prepared first

*Reaction of Staphylococcus aureus Broth Culture to Aqueous and 0.25  
Per Cent Dextrose Gentian Violet in the Incubator at 37.5 C  
and in the Water Bath at 50 C \**

	0 Min	2 Min	4 Min	6 Min	8 Min	10 Min	15 Min	20 Min	30 Min	40 Min	60 Min	120 Min
I Incubator 37.5 C												
1 Control	+	+	+	+	+	+	+	+	+	+	+	+
2 Aqueous gentian	+	+	+	+	+	+	+	+	+	+	+	+
3 Dextrose gentian	+	+	+	+	—	—	—	—	—	—	—	—
II Water bath 50 C												
1 Control	+	+	+	+	+	+	+	+	+	+	+	—
2 Aqueous gentian	+	+	+	+	—	—	—	—	—	—	—	—
3 Dextrose gentian	+	+	—	—	—	—	—	—	—	—	—	—

\* Dilution of gentian violet, 1 to 10,000

with distilled water as a medium and then with 4 per cent dextrose as a medium Sufficient amounts of the gentian violet preparations were added to the broth cultures to make a 1:10,000 dilution of the dye A bath at 50 C was used to give the increase in temperature A series of six broth cultures was used, divided as follows two contained aqueous gentian violet, two 4 per cent dextrose gentian violet, and two controls One set of three cultures was placed in the incubator at 37.5 C and one set in the water bath at 30 C Subcultures were taken immediately before adding the gentian violet, and at periods thereafter of five, ten, fifteen, twenty, thirty, forty, sixty minutes, and two hours

\*From the Louis Bowles Foundation of the Children's Hospital School, Baltimore

1 Churchman, J W Bull Johns Hopkins Hosp 33 277 (June) 1922

2 Gatch, W D, Trusler, H M, and Owen, J E Treatment of General Septicemia by Gentian Violet and Mercurochrome-220 Soluble, J A M A 85 894 (Sept 19) 1925

When the transfusion is finished, the operator should clean the apparatus. It should be placed in the cover, rolled up and sterilized in the autoclave immediately at 5 pounds' pressure for ten minutes. A convenient method is to autoclave the set under the same conditions observed for rubber gloves. Thus a sterile apparatus is always ready. A lubricant or coating should not be used for any part of the apparatus, and a new rubber tubing should be used for each transfusion. The apparatus can be used satisfactorily by one person if an assistant is not available. In that case the assistant's syringe is left in position but is disregarded when the transfusion has been started. Of course, an assistant is desirable to provide a steady flow of blood.

2201 Jefferson Avenue East

Plain agar plates were used for the subcultures. The cultures were noted in twenty-four and forty-eight hours. In the incubator the cultures did not show any growth in the aqueous gentian violet after sixty minutes, nor any growth in the 4 per cent dextrose gentian violet after five minutes. In the water bath there was no growth at any period in either the aqueous or 4 per cent dextrose gentian violet cultures, nor was there a growth in the control culture after sixty minutes. The experiment was now checked and the results obtained, except that in the water bath the aqueous gentian violet showed a growth at five minutes. An attempt was made to determine more nearly the time the cultures became sterile. The same experiment was repeated with subcultures made at two, four, six, eight, ten, fifteen and twenty minute intervals after the addition of the gentian violet. In the incubator there was no growth after six minutes in the 4 per cent dextrose gentian violet, while the aqueous gentian violet showed a growth in all cultures. In the water bath there was no growth after six minutes in the aqueous gentian violet, and no growth after two minutes in the 4 per cent dextrose gentian violet.

From this experiment it is concluded that dextrose gentian violet is more toxic for *Staphylococcus aureus* than aqueous gentian violet, and that heat has a definite effect on the bactericidal power of the gentian violet. *Staphylococcus aureus* is therefore destroyed quicker by gentian violet in 4 per cent dextroses than in sterile water, and in the presence of an increase in the surrounding temperature.



# STUDIES IN INTESTINAL OBSTRUCTION

\* II THE ABSORPTION OF HISTAMINE FROM THE OBSTRUCTED BOWEL

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AND

MILLO LOUCKS, PH.D.

MINNEAPOLIS

In intestinal obstruction, the factor of absorption from the bowel is uniformly acknowledged as being of the greatest importance. It is generally stated that with the stretching and damaging of the wall of the bowel incident to distention by obstruction, absorption of the toxic material from the bowel occurs to which the mucous membrane of the normal bowel is impermeable.

It has been adequately demonstrated that the obstructed bowel permits the absorption of substances from its lumen to which the normal bowel is permeable. Braun and Boruta<sup>1</sup> have been able to show that strychnine is absorbed from the obstructed intestine of the dog, but at a slower rate than from the normal intestine. Clairmont and Ranzi<sup>2</sup> found that potassium iodide was absorbed from the obstructed intestine of the dog more rapidly during the first ten hours following the obstruction than from the normal bowel. From ten to fifteen hours after the obstruction, the absorption became reduced in amount and quickly sank to a low level. Enderlen and Hotz<sup>3</sup> observed that the absorption of various concentrations of saline and dextrose in the obstructed intestine of the dog was retarded from the start, some time following the establishment of the obstruction, the absorption from the obstructed bowel was slight. Later during obstruction they observed an exudation of fluid into the bowel. Enderlen and Hotz<sup>3</sup> stated that in the animal with intestinal obstruction, the absorption from the nonobstructed segments is also diminished. In contrast to the greatly changed external appearance of the bowel in strangulation obstruction, Enderlen and Hotz found that there was little change from the normal bowel in the absorption of varying con-

\* From the Departments of Surgery and Physiology of the University of Minnesota

\* Presented before the Minnesota Pathological Society, April 19, 1927

1 Braun, W., and Boruta, H. Experimental kritische Untersuchungen ueber den Ileus Tod, Deutsche Ztschr f Chir 96 544, 1908

2 Clairmont P., and Ranzi, E. Zur Frage der Autointoxication bei Ileus, Arch f klin Chir 73 696, 1904

3 Enderlen and Hotz. Ueber die Resorption bei Ileus and Peritonitis, Mitt a d Grenzgeb d Med u Chir 23 755, 1911

The remaining sixty-three cases (58 per cent) formed a third group which was distinct from the other two in that the palpable nodules or tumors of the thyroid glands were composed of sharply localized areas of hypertrophy and hyperplasia while the intervening parenchyma of the thyroid presented the microscopic structure of a normal gland. In these cases, the morbid process had remained confined to certain localized, well defined areas of the gland instead of spreading diffusely throughout the thyroid as in the two groups of cases already described. The clinical histories in these cases revealed a low grade hyperthyroidism of long standing, with a relatively chronic course which manifested

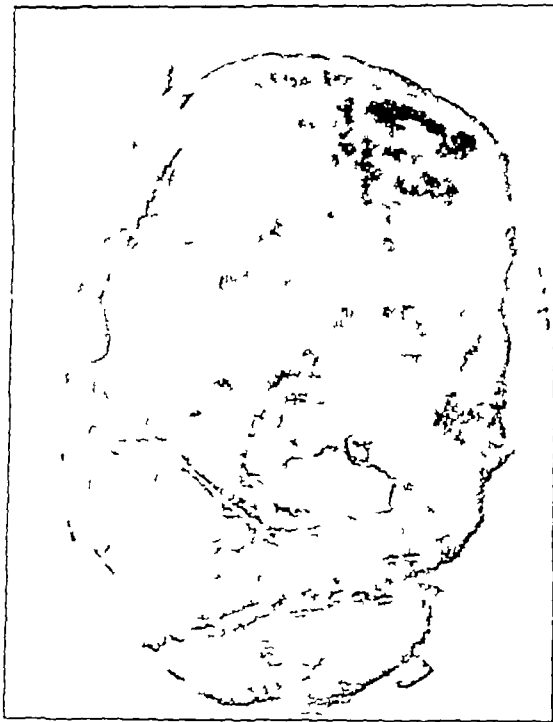


Fig. 25—Photograph of paraffin block of right lobe of thyroid removed from patient, aged 63, with basal metabolic rate of plus 60, nodular fibriation and a long history of hyperthyroidism. Specimen originally the size of a min-  
 fast, but lying in formaldehyde caused a great deal of shrinkage. The two  
 nodules at top of the picture are areas of hyperplastic parenchyma. The large  
 tumor occupying the greater part of the lobe was a white gray mass of fibrous  
 tissue cellular detritus, fat and a homogeneous mass. The tumor is outlined by  
 flattened normal thyroid parenchyma. The isthmus and left lobe of the thyroid  
 in this case were normal in appearance and a piece removed from each showed  
 a normal microscopic picture. The patient improved after removal of the right  
 lobe. She now has a normal basal metabolic rate and a normal heart rhythm.  
 Reduced to one-half its actual size.

itself more prominently in the fourth fifth and sixth decades. Clin-  
 ically and in the gross specimens the tumors or nodules of the thyroid  
 were readily palpable and varied in size from small shothike nodules

to tumefactions the size of a man's fist or even larger (fig 25) In the gross specimen on section these nodules formed sharply circumscribed areas with an apparent encapsulation, the thickness of which was usually proportionate to the duration of the disease and the age of the patient (fig 17) These tumors appeared to be composed of parenchymatous tissue and toward the center often contained small cysts or bluish-white stellate areas of connective tissue Microscopically, these nodules were seen to be composed of thyroid parenchyma in a state of hypertrophy and hyperplasia similar in all respects to that<sup>1</sup> observed throughout the gland as a whole in cases of exophthalmic goiter (figs 21, 26, 27 and 28) In the majority, the acini appeared to be larger

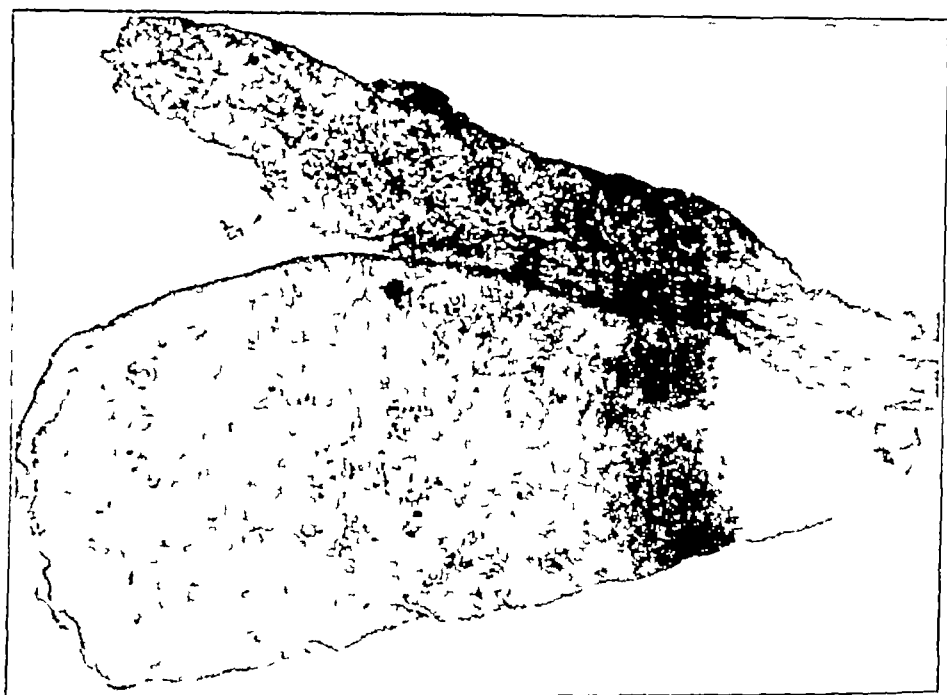


Fig 26—Low power photomicrograph of a tumor the size of a golf ball removed from the thyroid gland of a patient with hyperthyroidism In the upper portion of the section there is a spur of contiguous normal thyroid parenchyma removed with the tumor Reduced from a magnification of  $\times 8$

and of the lacelike type with the characteristic papillomatous infoldings (figs 22 and 29), yet in some the nodules were composed of a greater number of small, round acini, while in others both types of hyperplasia were noted (figs 30 and 31) The epithelium lining these acini showed the characteristic histologic changes associated with an increased functional activity of the cells—columnar shape, vacuolated cytoplasm with an increase in the mitochondria and vesicular, clear-staining nuclei Vacuolization was present in the colloid, which seemed less viscid than normal and stained poorly In the majority of cases, the hyperplastic and hypertrophic parenchyma was characteristic and in the best state

centrations of dextrose and saline Braeye,<sup>4</sup> in studying the passage of toxins obtained from an obstructed bowel through an isolated obstructed loop, was unable to determine any abnormal absorption with soap solution

The nature of the toxin in intestinal obstruction is a disputed point even among those who generally accept the absorption of an intestinal toxin as the cause of death Every one agrees, however, that if there is a toxin in the bowel of the animal in which intestinal obstruction has been produced which is not present in the intestine of the normal animal, the toxin has its source above the point of obstruction and probably takes origin in protein disintegration

In this study, histamine was placed in the intestine of both the normal dog and the dog with intestinal obstruction, and acute experiments were performed to test for the physiologic action of histamine as observed in the blood pressure Gerard<sup>5</sup> stated that the toxic substance in intestinal obstruction actually is histamine It is known, however, that histamine is present in the bowel of both man and the normal dog<sup>6</sup> and also in the bowel of the dog with intestinal obstruction<sup>7</sup> The eliciting of the physiologic test for histamine when injected into the bowel of the dog with intestinal obstruction would adduce convincing proof that the bowel of the animal was permeable to toxic substances which the normal bowel did not allow to pass

#### METHOD

Blood pressure tracings were recorded by a kymograph from the carotid artery of the dog under ether anesthesia After the pressure level had been established, the abdomen was opened, and the pressure level was again allowed to adjust itself following the transitory change that occasionally occurred when the abdomen was opened or a loop of bowel was raised Histamine dichloride was then injected into the

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4 Braeye, Louis Contribution to the Study of Toxic Absorption from the Intestinal Tract in Experimental High Obstruction, *Bull Johns Hopkins Hosp* **40** 33, 1927

5 Gerard, R. W Chemical Studies on Intestinal Intoxication, The Presence and Significance of Histamine in an Obstructed Bowel, *J Biol Chem* **52** 116, 1922, The Lethal Agent in Acute Intestinal Obstruction, *J A M A* **79** 1581 (Nov 4) 1922

6 Hanke, M T, and Koessler, K K Studies on Proteinogenous Amines, On the Presence of Histamine in the Mammalian Organism, *J Biol Chem* **59** 879, 1924 Meakins, J, and Harington, C R The Relation of Histamine to Intestinal Intoxication, I The Presence of Histamine in the Human Intestine, *J Pharmacol & Exper Therap* **18** 455, 1921 Mellanby An Experimental Investigation on Diarrhea and Vomiting of Children, *Quart J Med* **9** 165, 1916

7 Gerard R W (footnote 5, second reference)

of mercury and then by a gradual decline to 50 mm. at 3 30 The ligature was again loosened, and the pressure continued to fall At 3 35 the pressure was 30 mm Seven cubic centimeters of intestinal contents was now aspirated from the strangulated loop and injected into a mesenteric vein with a gradual decrease of pressure The dog died at 3 50

*Summary*—Strangulated obstruction of two hours' duration was established A marked fall in pressure occurred when the constriction was released When the ligature was tightened, a short rise in pressure occurred

EXPERIMENT 19 (dog 89)—Dec 30, 1926 Strangulated obstruction of a loop of the lower part of the ileum, together with its mesentery was performed under aseptic technique at 11 30 a m A carotid artery tracing was started at 2 p m under ether anesthesia The tracing from this experiment has also been lost, so that only the protocol written at the time is available, consequently, definite figures as to arterial pressure at any time cannot be given At the beginning of this experiment, the pressure was good At 2 05, the abdomen was opened without much effect on the pressure The bowel was only moderately cyanotic and rather thickened on palpation At 2 20, the ligature about the bowel and mesentery was loosened, with an immediate fall in pressure At 2 35, the ligature was tightened, and the pressure rose gradually At 2 50, the ligature was loosened again, and a slight but definite fall in the arterial pressure occurred Fifty milligrams of histamine was injected into the strangulated bowel at this time, apparently without direct effect on the pressure At 3 10, a portion of the contents into which the histamine had been injected was aspirated from the loop and injected into a mesenteric vein, causing a great fall in pressure

*Summary*—A strangulated obstruction was established for two and one-half hours Release of the constriction was attended by a fall in pressure On tightening the ligature, the pressure rose

EXPERIMENT 20 (dog 90A)—Dec 31, 1926 Aseptic strangulated gut obstruction was produced at 11 30 a m by tying off a loop of the ileum and mesentery about 5 feet (152.4 cm) in length The bowel was then irrigated with a solution of 10 per cent formaldehyde, ether and alcohol until the contents returned clear The dog was again anesthetized A tracing was started at 2 50 p m The dog was extremely ill The blood pressure at the beginning of the experiment was 118 mm of mercury, but fell gradually At 2 58, the abdomen was opened The arterial pressure went down to 90 mm of mercury The strangulated loop was raised The blood pressure at 3 10 was 50 mm and at 3 15, 48 mm The ligature was detached from the bowel and mesentery The blood pressure continued to fall at the same rate, and at 3 25 had dropped to 40 mm At 4, 10 mg of histamine was injected into a mesenteric vein, death followed

*Summary*—Strangulation obstruction of the intestine was established and maintained for three and one-half hours The pressure was low at the beginning of the experiment The dog was in a state of shock Release of ligature was accompanied by a continued decline in pressure

EXPERIMENT 21 (dog 92)—Dec 3, 1927 Strangulated obstruction of 5 feet or the bowel was established at 5 p m by tying off the bowel loop and mesentery with a gauze tie under aseptic technique The bowel was irrigated with 10 per cent formaldehyde, ether and alcohol until the contents returned clear The dog was anesthetized again with ether at 7 30 A tracing was begun at 7 42, the pressure being 210 mm of mercury (fig 7) The abdomen was opened at 7 50 The

lumen of the bowel with a fine hypodermic needle. This procedure was first carried out in the normal, and then in the obstructed ileum and duodenum. Blood pressure tracings were also obtained in a few dogs in which duodenal obstruction had been created two days previously without injecting histamine into the obstructed bowel at the time the observations on the blood pressure were made. A number of tracings were made on dogs in which strangulation obstruction had been established a few hours previously. In some of these experiments, histamine was injected into the bowel before the strangulating mechanism was released, in others, the introduction of histamine into the bowel was omitted.

In a few of the early experiments the tracings were made under a combination of morphine and local anesthesia, and the pressure was obtained from the femoral artery. In most of the tracings, however, ether anesthesia was employed, and the pressure was recorded from the carotid artery. Unless otherwise specified, it is implied that the blood pressure was registered from the carotid artery and that ether anesthesia was used. Whenever the intestines were obstructed by operation quite an interval prior to the time that the tracing was made, aseptic technic was employed, and the animals were allowed to recover from the anesthetic before the second procedure was begun. Severed gut obstructions were established by cutting across the bowel and inverting the ends. Strangulation obstructions were created by placing a gauze ligature around a loop of bowel, from 3 to 5 feet (91.44 to 152.4 cm) in length, together with its mesentery. The degree of constriction obtained by the ligature was varied. In a few instances in which complete cessation of blood flow was desired, Carmalt noncrushing clamps were placed across the mesentery. In this study, pressure readings were made on twenty-eight dogs.

#### EXPERIMENTS

EXPERIMENT 1 (dog 71) —Nov 27, 1926 Absorption of histamine from the normal duodenum

A tracing was made on a large female collie with a cannula in the right femoral artery under ether anesthesia at 12 40 p m. The blood pressure at the beginning of the tracing was 124 mm of mercury. The abdomen was opened and the duodenum isolated by clamping off a segment about 8 inches (20.3 cm) in length with intestinal clamps cross the bowel. At 1 10, 10 mg of histamine was injected into the femoral vein with only a slightly perceptible change in the arterial pressure. At 1 20, 10 mg of histamine was injected into a mesenteric vein with an immediate depression of the pressure to 75 mm of mercury. At 1 40, the blood pressure had risen to 90 mm of mercury. Ten milligrams of histamine was then injected into the femoral vein with a drop in pressure to 50 mm of mercury. After twenty minutes, the pressure rose to 90 mm of mercury, and 50 mg of histamine and enough water to make the obstructed loop of the intestine tense, was injected into it. Change in the

arterial pressure was 200 mm. The strangulated loop was moderately cyanotic and discolored with some free hemorrhagic fluid present in the peritoneal cavity. The strangulated loop was carefully delivered and isolated in warm saline packs placed on the abdominal wall. At 8 10 the pressure was 180 mm of mercury. The ligature about the bowel and the mesentery was loosened at 8 13, with an almost immediate fall in pressure to 140 mm. The vessels to the strangulated bowel were soon pulsating, and at 8 20, the normal luster had returned to the strangulated loop, and the pressure was 132 mm of mercury. At 8 35, the pressure had fallen to 104 mm. The ligature on the intestine was tightened again. Ten minutes later, at 8 45, the bowel was again moderately cyanotic. The pressure had risen to 110 mm. At 8 55, the pressure remained unchanged, at 9 05, the pressure had arisen to 118 mm, and the constriction on the bowel and the mesentery was loosened again. At 9 10, the color had returned to the bowel, and the vessels were pulsating. The pressure had fallen to 100 mm, and at 9 25 had dropped to 80 mm. Twenty cubic centimeters of intestinal contents was then aspirated from a normal loop, diluted with a little saline solution and injected into a mesenteric vein. The arterial pressure had continued to fall and was then 54 mm. Ten minutes later, the dog was dead.

*Summary*—A strangulated obstruction was established and had been maintained for three and one-half hours. The pressure was good when the tracing was started. A release of the constriction was attended by a sudden primary and gradual reduction of pressure. When the ligature was tightened the pressure rose

EXPERIMENT 22 (dog 140)—March 8, 1927. A large collie was used in this experiment. The tracing was started at 10 40 a m. The blood pressure was 200 mm of mercury. The abdomen was opened at 10 50. At 10 55, the mesentery to a loop of the midileum, about 3 feet in length, was clamped off with two Carmalt hemostatic forceps so as completely to deprive this segment of its blood supply. At 12 20, one hour and twenty-five minutes later, the two clamps were released without any alteration in pressure. At 1 25, the blood pressure was unchanged. Air was injected into the left ventricle, death resulted.

*Summary*—Strangulation of a loop of the intestine was established at the time of operation. Release of the ligature one hour and twenty-five minutes later did not show a fall in pressure.

EXPERIMENT 23 (dog 145)—April 13, 1927. A loop of the intestine was strangulated for 30 inches (76.2 cm) by placing clamps on the mesentery at 10 30 a m. A tracing was started at 4 23 p m under ether anesthesia, the clamps were removed at 4 43 (fig 8). The bowel was markedly discolored. From the time the clamps were loosened, the pressure gradually fell. About twenty-five minutes after loosening the clamps, the bowel was regaining luster, but the blood pressure continued to decrease, and the dog died at 5 53, one hour and ten minutes after the removal of the clamps. The pressure at the beginning of the tracing was 150 mm, at 4 36, just after opening the abdomen, 132 mm, at 4 43, when the clamp was loosened, 140 mm, ten minutes after loosening the clamp, 100 mm, at 5 03, 84 mm, at 5 13, 75 mm, at 5 23, 60 mm, at 5 33, 50 mm, at 5 43, 40 mm, and at 5 50, 20 mm. Death occurred at 5 53.

*Summary*—A strangulation obstruction was established and maintained for six hours. The pressure was good at the beginning of the experiment. After the clamps were released, there was a gradual reduction in pressure followed by death in one hour and ten minutes.

EXPERIMENT 24 (dog 146)—April 16, 1927. Strangulation obstruction of the intestine was established at 10 30 a m by ligating 4 feet of the midileum. A

blood pressure did not occur over a half hour period. Ten milligrams of histamine was then injected into a mesenteric vein with an immediate reduction of pressure to 44 mm, death resulted.

*Summary*—A physiologic effect was obtained when histamine was injected intravenously into the systemic and into the mesenteric veins. The injection of 50 mg of histamine into the duodenal loop which had been made tense by distending it with water did not have any effect.

EXPERIMENT 2 (dog 79)—Dec 20, 1926 Absorption of histamine from the normal ileum

A tracing was started at 10 17 a m (fig 1). The arterial pressure was 140 mm. At 10 34, the abdomen was opened, the pressure being 150 mm. At 10 48, rubber covered clamps were applied 3 feet apart across the lower part of the ileum. At 10 55, the pressure was 130 mm. At 10 57, 50 mg of histamine and enough water to make the loop distended was injected into the intestine with a fine hypodermic needle. At 11 07, the arterial pressure was 128 mm. The pressure continued at the same level. At 12 04 p m, one hour and nine minutes following the injection of the histamine into the lower ileal loop, the pressure was still unchanged. Ten milligrams of histamine was then injected into a mesenteric vein with an immediate fall of pressure to 70 mm. At 12 09, 1 cc. was aspirated from the loop into which the histamine had been injected, with a quick fall in pressure to 56 mm, followed by a progressive decline. The dog was killed with ether.

*Summary*—A fall in pressure did not occur after one hour and nine minutes following the injection of 50 mg of histamine into the normal loop of the ileum.

EXPERIMENT 3 (dog 80)—Dec 20, 1926 Aseptic gut obstruction (lower part of the ileum) was established at 11 a m

A tracing was started December 21, at 3 06 p m. The arterial pressure was 110 mm of mercury. The abdomen was opened at 3 12, and six minutes later the arterial pressure was 136 mm. A rubber covered clamp was applied across the bowel about 18 inches (45.7 cm) proximal to the obstruction in the ileum. The blood pressure at 3 25 was 130 mm of mercury. At 3 26, 50 mg of histamine was injected into the obstructed loop. At 3 32, the blood pressure was the same. At 3 45, 3 54 and 4 07, the systolic pressure was 130 mm. At 4 17 the blood pressure was 124 mm of mercury. At 4 30, the blood pressure dropped to 118 mm of mercury, and 25 mg more of histamine was injected into the obstructed loop. At 4 45, the blood pressure was 110 mm, at 4 57, it remained the same. Three cubic centimeters of contents from the obstructed loop containing histamine was then injected into a mesenteric vein with an immediate fall in pressure to 56 mm. At 5 03, the blood pressure had gradually returned to 80 mm. Three cubic centimeters of intestinal contents was then aspirated from the colon and injected without effect. At 5 15, the blood pressure was 70 mm of mercury. Three cubic centimeters were aspirated from the obstructed loop containing histamine and injected into a mesenteric vein with a fall to 40 mm of mercury. Air was injected into the heart, death resulted.

*Summary*—A fall in pressure did not occur in one hour in the dog with severed ileal gut obstruction of twenty-four hours' duration after 50 mg of histamine was placed in the bowel.

EXPERIMENT 4 (dog 72)—Nov 30, 1926 Aseptic severed duodenal gut obstruction was established at 11 a m

On December 1, at 11 55 a m, a tracing was started under procaine hydrochloride anesthesia from the right femoral vein of the abdominal wall after a



tracing was started at 1 48 p m. The blood pressure was 160 mm of mercury. The abdomen was opened at 1 50 and the ligated loop was found to be very dark. The strangulated loop was opened near one end, and as much of the material in the lumen as possible was pressed out, following this, the loop was irrigated with water until the contents, although slightly hemorrhagic in appearance, returned fairly clear. The blood pressure was 160 mm of mercury. At 2 02, the obstructing mechanism was released, and the pressure promptly fell to 130 mm of mercury. At 2 05, the clasper was returning to the bowel, and the vessels were pulsating. The pressure had fallen to 108 mm of mercury. Following this, there was a gradual rise to 130 mm of mercury at 2 10, with a fall at 2 12 to 98 mm of mercury. At 2 15, the blood pressure had risen to 130 mm of mercury, and was apparently sustaining itself at this level. The contents that had previously been aspirated were replaced in the bowel at 2 20 without any effect on the pressure. At 2 22, the blood pressure was 124 mm of mercury. At 2 24, 15 mm of histamine was injected into the bowel without apparent effect. The constricting mechanism at this time was tightened, and the blood pressure rose at 2 45 to 140 mm of mercury. At 2 49, the constricting mechanism was released, and the pressure promptly fell to 110 mm of mercury. At 2 55, some of the contents were aspirated from the strangulated loop and injected into the mesenteric vein, this was followed by a prompt fall in pressure to 50 mm of mercury, death then occurred.

*Summary*—A strangulation obstruction of the gut was established and maintained for three and one-half hours. Release of the constriction was accompanied by a sharp and definite fall of arterial pressure, even after the contents of the obstructed bowel were washed out. When the constriction was again placed about the bowel and the mesentery, the pressure rose. Release of the strangulating mechanism was again accompanied by a decided fall in pressure. Neither the replacement of the removed intestinal contents in the bowel nor the injection of 15 mg of histamine into the strangulated bowel accelerated the fall in pressure.

EXPERIMENT 25 (dog 114)—Feb 3, 1927. A tracing from the carotid artery was started at 3 40 p m under ether anesthesia. The pressure was 230 mm of mercury. The abdomen was opened at 3 55. At 4 10, 4 cc. of peritoneal fluid from a dog with a strangulated gut obstruction<sup>2</sup> was injected into the mesenteric vein with only a slight and transient fall in arterial pressure. At 4 23 another injection of 4 cc was made with the same result. At 4 32, 15 cc. was injected with a more definite but transient fall of pressure to 176 mm of mercury. At 4 50, the blood pressure was 200 mm. Fifteen milligrams of histamine was now injected into a mesenteric vein, resulting in a sudden and sustained fall to 130 mm. At 5 15 death was produced by asphyxia.

*Summary*—A slight and transient fall of pressure occurred after the injection of peritoneal fluid from an autolyzed loop of the intestine into the mesenteric vein of the dog. Sustained reduction was produced by the injection of 15 mg of histamine into the mesenteric vein.

8 The origin of the fluid is as follows. A piece of midileum about 12 inches (30.48 cm) in length weighing 73 Gm was removed from one dog and placed in the peritoneal cavity of another after the bowel was irrigated until the contents returned clear. This segment of the bowel was then opened along the antimesenteric border, and the mucosa was washed and scrubbed. When the dog into the peritoneal cavity of which this loop was placed died, two days later, this hemorrhagic fluid was obtained for injection.

previous subcutaneous injection of 240 mg of morphine sulphate, pressure at this time was 154 mm of mercury. At 11 58, the abdomen was opened. The pressure remained unchanged. At 12 00, 100 mg of histamine was injected into the obstructed duodenal loop. A rubber covered intestinal clamp was applied across the gut at the pylorus. At 12 15 p m, the pressure was still 154 mm of mercury. At 12 17, a clot was removed from the vessel, following which there was a fall in pressure to 120 mm of mercury. At 12 22, another clot was removed from the vessel, the pressure, meanwhile, having fallen to 80 mm of mercury. At 12 32, the histamine was removed from the bowel by aspiration, without any change in pressure. At 12 47, one fourth of the material removed

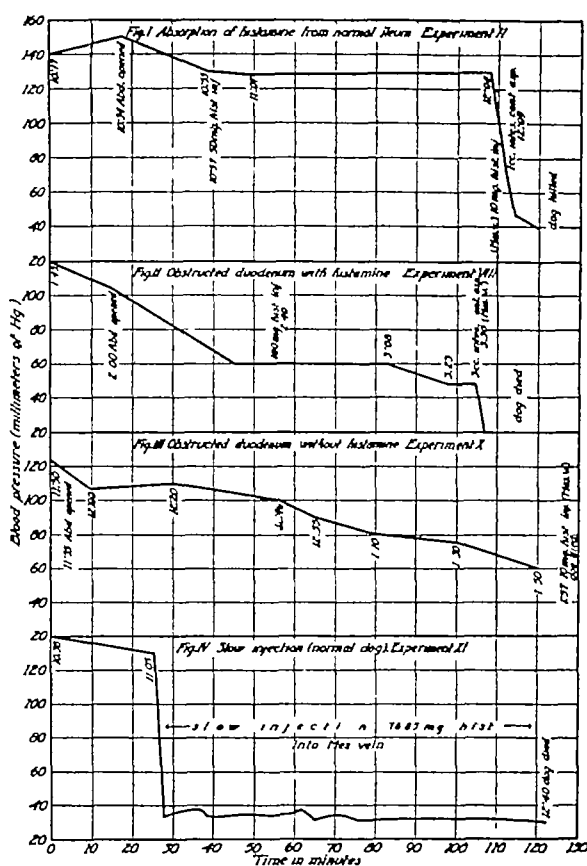


Chart 1—Figure 1, experiment 2, is the blood pressure curve showing that the placing of histamine in the normal ileum did not cause any effect, figure 2, experiment 8, blood pressure tracing showing the effect of placing histamine in the obstructed duodenum, figure 3, experiment 10, blood pressure tracing showing the effect of obstruction without injecting histamine in the bowel, and figure 4, experiment 11, blood pressure tracing showing the effect of extremely slow injection of histamine intravenously

from the loop was injected into a mesenteric vein, causing an immediate drop in pressure almost to the base line, death followed at 12 58

**Summary**—A gradual fall of pressure occurred after the introduction of 100 mg of histamine into the duodenal loop of a dog with a two day severed gut duodenal obstruction

EXPERIMENT 26 (dog 133)—Feb 21, 1927 An aseptic ligation of the aorta and vena cava was performed above the bifurcation with gauze at 12 45 p m, two ileolumbar vessels on each side were also ligated to diminish peripheral inoculation. When the dog was anesthetized again, he could not stand up, owing to the anemia and consequent paralysis of the hind extremities. A tracing was started at 3 30 p m. The blood pressure at this time was 200 mm of mercury. At 3 45, the ligature was removed from the aorta without effecting a change in pressure. At 3 50, the ligature was removed from the vena cava without any change in the blood pressure for over an hour.

*Summary*—A ligation of the aorta and the vena cava was performed. Three hours later, there was no reduction in blood pressure following release of the constriction.

EXPERIMENT 27 (dog 135)—Feb 28, 1927 At 11 00 a m, a Carmalt clamp was applied across the splenic pedicle and another across the right renal vessels of a dog. A tracing was begun at 3 20 p m with the cannula in the right carotid artery. The blood pressure was 240 mm of mercury. The abdomen was opened at 3 25, and the spleen was found to be bluish and soft with free hemorrhagic fluid in the peritoneal cavity. At 3 40, the clamp was removed from the splenic vessels. Red spots began to appear on the external surface of the spleen, and the organ became firm in consistency. At 3 55, the blood pressure was 190 mm of mercury. At 4 05, the clamp was removed from the pedicle of the right kidney without any change in pressure. At 4 25, when the tracing was discontinued, the blood pressure remained at 190 mm of mercury.

*Summary*—A moderate fall in pressure occurred following the release of the clamp on the splenic pedicle which had been placed there more than four hours previously. When the clamp placed on renal pedicle five hours previously was released, a fall in pressure did not occur.

EXPERIMENT 28 (dog 136)—March 5, 1927 A tracing was started at 3 40. The blood pressure was 250 mm of mercury. At 3 50, 50 mg of histamine was injected subcutaneously over the wall of the chest. There was a gradual but definite fall of pressure to 200 mm of mercury at 3 52. At 4 o'clock, the blood pressure had dropped to 170 mm of mercury. Fifty milligrams more of histamine was injected subcutaneously over the wall of the chest. The blood pressure at 4 01, was 160 mm of mercury. At 4 05, it had fallen to 150 mm. The pressure was maintained at this level, and the experiment was discontinued.

*Summary*—A definite fall of pressure occurred following subcutaneous injection of histamine.

## SUMMARY

When from 50 to 100 mg of histamine was placed in the duodenum or ileum of normal dogs, a fall in pressure was not observed in any of the four animals for a period of an hour or more following the introduction of the drug. The injection of from 3 to 10 mg of histamine into a mesenteric vein was always followed by a sharp fall in pressure. When a few cubic centimeters of the intestinal contents were aspirated from the loops of the bowel into which histamine had been introduced and were injected into a mesenteric vein, there was a sudden fall in arterial pressure, which characterized the histamine reaction.

In a dog with a severed gut obstruction in the lower part of the ileum of thirty hours' duration, the arterial pressure after the introduction of

EXPERIMENT 5 (dog 73) —Dec 2, 1926 Aseptic severed gut duodenal obstruction was established at 10 30 a m

At 12 06 p m, a tracing was started under morphine and procaine hydrochloride anesthesia of the abdominal wall, the dog having thirty minutes previously been injected hypodermically with 140 mg of morphine. The blood pressure at this time was 140 mm of mercury. The abdomen was opened at 12 10. At 12 13, 100 mg of histamine was injected into the obstructed duodenal loop. The blood pressure was 118 mm of mercury. At 2 25, the blood pressure was unchanged. At 12 38, the anesthesia proved insufficient and ether was administered. At 12 50, 80 mg of morphine was again given hypodermically in an endeavor to carry on the experiment without ether. At 1 o'clock, the blood pressure was 80 mm of mercury and the experiment was discontinued because of unsatisfactory anesthesia.

EXPERIMENT 6 (dog 74) —Dec. 6, 1926 Aseptic severed duodenal obstruction was established at 2 30 p m

A tracing was started under ether anesthesia (no morphine) on December 7, at 11 40 a m, pressure being recorded from the right femoral artery. At the beginning of the tracing, the pressure was 120 mm of mercury. The abdomen was opened at 11 50. The obstructed duodenal loop was raised and an intestinal clamp applied across the pylorus at 11 58. The blood pressure was 120 mm at 12 06 p m. At 12 15, a clot was removed from this vessel, and the cannula was transferred to the left femoral artery. The blood pressure was 128 mm of mercury. At 12 30, another clot formed, and the cannula was removed and placed in the right carotid artery. At 12 45, the blood pressure was 128 mm of mercury. Three milligrams of histamine mixed with a little of the intestinal contents from a normal loop was then injected into a mesenteric vein, this was followed by an immediate drop in pressure to 30 mm. A gradual rise then followed, which reached 90 mm of mercury at 1 15. A slow but gradual fall in pressure occurred during the next hour. At 2 10, the blood pressure was 60 mm of mercury. At 2 22, the arterial pressure had fallen to 40 mm. At this time, 50 mg of histamine was injected into a normal loop of the ileum, and intestinal clamps were applied across the bowel about a foot apart. A slow fall in pressure continued, death resulted at 2 35.

*Summary*—Duodenal obstruction was established and continued for twenty-one hours. The physiologic effect of histamine was noted after the injection of 3 mg of this drug into the mesenteric vein. Histamine was not placed in the obstructed duodenal segment. The pressure fell gradually from the beginning of the tracing. The injection of 50 mg into a normal ileal loop did not accelerate the drop.

EXPERIMENT 7 (dog 81) —Dec 20, 1926 Severed gut obstruction was established in the lower part of the ileum at 11 a m

On December 21, the dog was given 300 cc of a 3 per cent sodium chloride solution subcutaneously, when the tracing was made on December 22, the animal was in relatively good condition. Unfortunately, the tracing was lost, so measurements of the arterial pressure at any given time are not available. The following record of the experiment was written at the time the tracing was made. At 1 p m, when the tracing was started, the blood pressure was good. The abdomen was opened and the obstructed loop delivered. A rubber covered clamp was applied across the bowel about a foot proximal to the obstruction. One hundred milligrams of histamine was then injected with a fine hypodermic needle into the lumen of the bowel. Fall in pressure was not observed over an interval of one hour and fifteen minutes. At this time, a little of the intestinal contents

first, 50 mg and then of 25 mg more of histamine into the bowel was the same as it had been two hours previously when the experiment was begun. In another ileal obstruction of two days' duration, the dog was given 300 cc of a 3 per cent sodium chloride solution subcutaneously on the intervening day in order to improve his condition for the tracing, no fall in pressure was noted after one hour and fifteen minutes following the introduction of 100 mg of histamine into the obstructed bowel.

In five dogs, duodenal severed gut obstructions of two days' duration were established before the tracings were made. In three instances, 100 mg of histamine was placed in the obstructed loop at the time the blood pressure readings were made. In one instance, histamine was not introduced into the bowel. In another dog, 50 mg of histamine was placed in a normal loop in the ileum. In all five instances, a gradual reduction of blood pressure occurred. This effect was just as striking when histamine was not introduced into the obstructed loop. In two of the three instances in which histamine was placed in the obstructed segment, a great reduction of arterial pressure had occurred before the histamine had been injected into the obstructed bowel. Following the introduction of the histamine, no acceleration of this reduction was observed. It must be remembered that a dog with a duodenal obstruction of forty-eight hours' duration is not a good risk for a blood pressure tracing when the abdomen has been opened under either anesthesia. These dogs usually survive the obstruction only about seventy-two hours. The gradual decline in pressure observed in these animals is probably thus best accounted for.

Histamine was slowly injected into a mesenteric vein of a normal dog and into a mesenteric vein of a dog with a duodenal severed gut obstruction of two days' duration. Histamine was introduced at the rate of 0.83 mg a minute. One hundred milligrams of histamine was dissolved in 100 cc of water, and the rate of the flow was so gaged that 100 mg would be injected every two hours (min 120). In both instances, a great and sustained fall of pressure occurred when the injection was begun. In another experiment in which the slow injection method also was practiced, but with interruptions, the same reduction in arterial pressure followed by a recovery on suspending the injection, was noted. When the instillation was resumed, the pressure fell, when discontinued again, a rise of the arterial pressure was observed. In all of the foregoing tracings made on normal dogs and those with severed gut obstruction, when histamine was introduced into the bowel, the consequence of increasing the pressure in the loop until it was tense by distending it with air and water was tested. No effect was observed. In another instance in which 100 mg of histamine was placed in a segment of bowel in a normal animal under a measured sustained pressure of 80 mm of mercury, reduction of the blood pressure had not occurred after an hour's observation.

from the ileum below the severed obstruction was aspirated and injected into the mesenteric vein without much effect. The same procedure was followed with a little of the contents of the loop proximal to the clamp which had been applied across the bowel. No great effect followed this injection. A few centimeters of the contents was then aspirated from the loop in which the histamine had been placed, and this was injected into a mesenteric vein and resulted in a great fall in pressure and in the death of the animal.

*Summary*—A severed gut obstruction was established low in the ileum and maintained for two days. The dog was given saline solution subcutaneously on the day following the obstruction, without a fall in pressure after one hour and fifteen minutes following the introduction of 100 mg of histamine into the loop of the obstructed bowel.

EXPERIMENT 8 (dog 90)—Jan 3, 1927. Duodenal obstruction was established in the dog at 3 p. m. A tracing was started on December 5, at 1 45 p. m. (fig 2). The arterial pressure was 120 mm. The abdomen was opened at 2 o'clock. The blood pressure was 104 mm. At 2 17, the loop was raised. The blood pressure was 98 mm. The duodenal loop was delivered and covered with warm packs of saline solution. A rubber covered clamp was then applied across the duodenum at the pylorus. In the meantime, the blood pressure had fallen to 60 mm of mercury. At 2 40, 100 mg of histamine was placed in the obstructed duodenal loop, the blood pressure had been falling gradually from the start. Acceleration was not noted, following this injection of histamine. At 3 08, the blood pressure was 60 mm and at 3 23, 48 mm. At 3 30, 3 cc. of intestinal contents was aspirated from the obstructed loop and injected into a mesenteric vein with an immediate drop of pressure to 20 mm. At 3 40, the dog was dead.

*Summary*—A duodenal severed gut obstruction was maintained for two days. There was a gradual fall in pressure from the start. Acceleration did not occur following an injection of 100 mg of histamine into the obstructed loop.

EXPERIMENT 9 (dog 95)—Jan 6, 1927. Aseptic duodenal obstruction was established at 3 p. m. Two days later a tracing was started at 12 50 p. m. The blood pressure was 124 mm. The abdomen was opened at 1 o'clock, and the duodenal loop was delivered at 1 10. One hundred milligrams of histamine was injected into the obstructed bowel at 1 20. The blood pressure was 130 mm of mercury at 1 30. At 1 40, 108 mm., at 1 45, 90 mm., and at 2 10 it remained unchanged. A large portion of the contents of the obstructed loop into which histamine had been injected were then aspirated and injected into a mesenteric vein with an immediate drop in pressure to 50 mm of mercury. Death occurred at 2 15.

*Summary*—A severed gut duodenal obstruction was maintained for two days with a gradual decrease in pressure following an injection of 100 mg of histamine into the obstructed bowel.

EXPERIMENT 10 (dog 97)—Jan 10, 1927. Obstruction was established in the dog at 2 p. m. by severing the duodenum and turning in the ends of the bowel just below the pancreatic ducts. A tracing was started on January 12 at 11 50 a. m. (fig 3). The arterial pressure was 124 mm. The abdomen was opened at 11 55. At 12 o'clock, the arterial pressure was 106 mm. At 12 20, the arterial pressure was 110 mm of mercury. Histamine was not injected into the bowel in this experiment. The blood pressure was 100 mm at 12 46, at 12 55, 90 mm, at 1 10, 80 mm, at 1 30, 76 mm, and at 1 50, 60 mm. At

Tracings were made on eleven dogs in which strangulation obstruction were established by tightly constricting from 3 to 5 feet of the bowel and its mesentery with a gauze tie or by applying Carmalt forceps across the mesentery. In four instances, the strangulation was effected after the tracing was commenced. In the other animals, the strangulation was established aseptically at a period varying from two to six hours before the tracing was begun. Discoloration and thickening of the strangulated segment was noted in all instances. In a few dogs free fluid (hemorrhagic) was present in the peritoneal cavity. In two instances, histamine was injected into the strangulated bowel before the constricting mechanism was released. In the others, the effect on the blood pressure was noted when the ligature was loosened. In two animals with strangulation obstructions, the strangulated loop was irrigated until the contents returned clear at the initial operation. In another instance, the strangulated loop was irrigated until the contents returned clear at the time that the tracing was made, just before the constriction was released.

In every instance in which the strangulation had been established at some time previous to the recording of the blood pressure with a kymograph, a definite and great fall in pressure accompanied the release of the constriction, with a return of the normal luster to the bowel and pulsations in its vessels. This was obtained whether or not histamine had been placed in the bowel prior to the time the ligature was removed. Previous irrigations of the bowel did not obviate the reduction of the pressure when the strangulating mechanism was released. Subsequent injection of histamine into the damaged loop did not appear to accelerate the fall in pressure. When the ligature was reapplied about the strangulated bowel and mesentery, the reduction in pressure usually ceased, the pressure either maintained itself at the previous level, or, what seemed to be more common, exhibited a definite rise. Loosening of the ligature again after an interval of time almost invariably was followed by a decline of the arterial pressure.

In one of the four instances in which the strangulation was established at the time the tracing was made, a fall in pressure was not observed when the strangulation was released. A total anemia of a loop was created in this dog by clamping the mesentery with Carmalt forceps. In two other instances, repeated loosening and tightening of the ligature in these strangulations of shorter duration brought about a slow but gradual reduction of the blood pressure. In one of the animals (dog 15), however, a strangulation of only twenty minutes effected a material reduction in pressure. Fifteen minutes after the release of the constriction, a great reduction occurred. The pressure rose when the constriction was reapplied.

1 57, 10 mg of histamine was injected into a mesenteric vein, this was followed by irregular respirations and death occurred in three minutes

*Summary*—A severed gut duodenal obstruction was maintained for two days. There was a gradual fall in pressure from the time the abdomen was opened and the tracing started. Histamine was not placed into the bowel. Ten milligrams of histamine injected into the mesenteric vein killed this dog in two hours and two minutes after the abdomen was explored.

EXPERIMENT 11 (dog 142)—March 30, 1927. Histamine was slowly injected into the mesenteric vein of a normal dog by a dripping mechanism so that the rate of the flow could be accurately determined (fig 4). One hundred milligrams of histamine was placed in 100 cc of water. The rate of the flow was so gaged that 100 cc would run in in one hundred and twenty minutes (two hours). At the end of sixty minutes, 50 cc had been injected. The tracing of the pressure was started at 10 38 a m. A slow injection was begun at 11 05. Immediately there was a marked reduction in pressure. The pressure was sustained at this low level till death at 12 40 p m. when 76.85 mg of histamine had been injected at the rate of 0.83 mg per minute. At the beginning of the experiment, the pressure was 140 mm, after opening the abdomen, 120 mm, and when slow injection was started, 130 mm. A few seconds after injection was begun, the pressure fell to 30 mm. Occasionally it rose to 40 or 50 mm, but it continued at low level till death.

*Summary*—Eighty-three hundredths milligrams of histamine was injected into a mesenteric vein of a normal dog per minute. The pressure fell at once to a low level and was sustained by a continuous slow injection. Ninety-five minutes later, when 76.85 mg of histamine had been injected, death occurred.

EXPERIMENT 12 (dog 143)—April 1, 1927. A slow injection of histamine was made into a mesenteric vein of a dog in which intestinal obstruction had been established two days previously (duodenal obstruction). A tracing was started at 9 35 a m (fig 5). The abdomen was opened at 9 50. Slow injection was begun at 10 06. At 12 07 p m, 100 mg, had been injected. Death occurred at 12 17. At the beginning of the experiment the pressure was 140 mm. After opening the abdomen, the pressure was 135 mm, and at 10 06, when the injection of histamine was begun, 130 mm. There was a sudden drop to 80 mm about a minute after slow injection was started. In a few minutes, the pressure rose to 94 mm. One hour after slow injection had been started, the pressure fell to 65 mm. When 100 mg had been injected by this method at 12 07 p m, the pressure was 60 mm. Death occurred at 12 17.

*Summary*—Histamine was slowly injected into the mesenteric vein of a dog with a duodenal obstruction of two days. A gradual decline occurred after a sharp initial fall in the arterial pressure.

EXPERIMENT 13 (dog 144)—April 22, 1927. (1) Absorption of histamine from the normal bowel under a measured pressure of 80 mm, (2) interrupted slow injection of histamine into a mesenteric vein. A tracing was started at 10 55 a m at a pressure of 140 mm (fig 6). The abdomen was opened at 11 02 a m, the pressure was 130 mm. Following the opening of the abdomen, the pressure fell to 90 mm. At 11 10 a m, the pressure had risen to 100 mm, and rubber covered clamps were applied across the bowel to a segment of the upper part of the jejunum about 2 feet (60.9 cm) in length. One hundred milligrams of histamine was injected into the segment of the bowel, and a measured water pressure of 80 mg of mercury was established in the segment. The pressure rose to 110 mg of mercury at 11 20 a m. When the pressure was discontinued at 12 10



The subcutaneous administration of 50 mg of histamine brought about a gradual but definite fall in blood pressure in the one dog in which this procedure was carried out. Repetition of the injection occasioned a similar sustained fall of arterial pressure.

The injection into a mesenteric vein of peritoneal fluid from a dog in the peritoneal cavity of which a sterile loop of bowel removed from another dog had been allowed to autolyze, was accompanied by only a slight and transient fall in pressure. When the splenic pedicle was clamped off in another animal, release of the clamp almost five hours later was followed by only a slight and transient fall in the arterial pressure. A release of the constriction applied across the pedicle of the right kidney in the same dog, a few minutes later (more than five hours after the clamp had been placed on the renal vessels) was not attended by a change in pressure. In a dog in which both the aorta and vena cava had been clamped off two and one-half hours previously, change in pressure did not follow the removal of the clamps over a period of an hour. At the time the tracing was started, the dog was unable to stand because of the anemia in the hind quarters.

## COMMENT

In these experiments, no evidence was obtained that histamine was absorbed from the normal bowel or from the dog with a severed gut obstruction, at any rate, the physiologic reaction that accompanies intravenous or subcutaneous administration of histamine, was not observed on the introduction of histamine into the bowel. If any absorption of histamine did occur from either the normal or the obstructed bowel, it was not absorbed as histamine. The immediate drop in pressure following the introduction of a few milligrams of histamine into a mesenteric vein demonstrates that the detoxifying influence of the liver is not great for histamine. If histamine was absorbed, it was detoxified in passing through the wall of the bowel. That the histamine did not disappear entirely from the bowel is demonstrated by the fact that aspiration of a few cubic centimeters of the contents of the bowel from the loop into which the histamine had been injected was always attended by a sharp fall in pressure that characterizes histamine action. This fall in pressure was always much greater than when intestinal contents alone were injected.

Hanke and Koesler<sup>6</sup> have been able to show by quantitative chemical tests for histamine that small quantities may be transported to the liver from the intestine in the normal animal. They have found that histamine is present as a normal constituent of the contents of the large intestine in both man and dog. They were able to isolate 53 mg of histamine in 150 mg of feces from a dog. From the liver of the same animal, 6 mg of histamine was obtained. They were unable to find

p m, one hour after the histamine had been injected, the pressure was 120 mm of mercury. Interrupted slow injection of histamine into the mesenteric vein was then begun two minutes later. At this time, after 8.33 mg of histamine had been injected, the systolic pressure fell to 60 mm. The slow injection was then discontinued, and in ten minutes the arterial pressure had risen to 100 mm. The slow injection was started again, and in ten minutes the pressure had fallen to 44 mm of mercury. The injection was again discontinued, and after ten minutes the pressure was 100 mm.

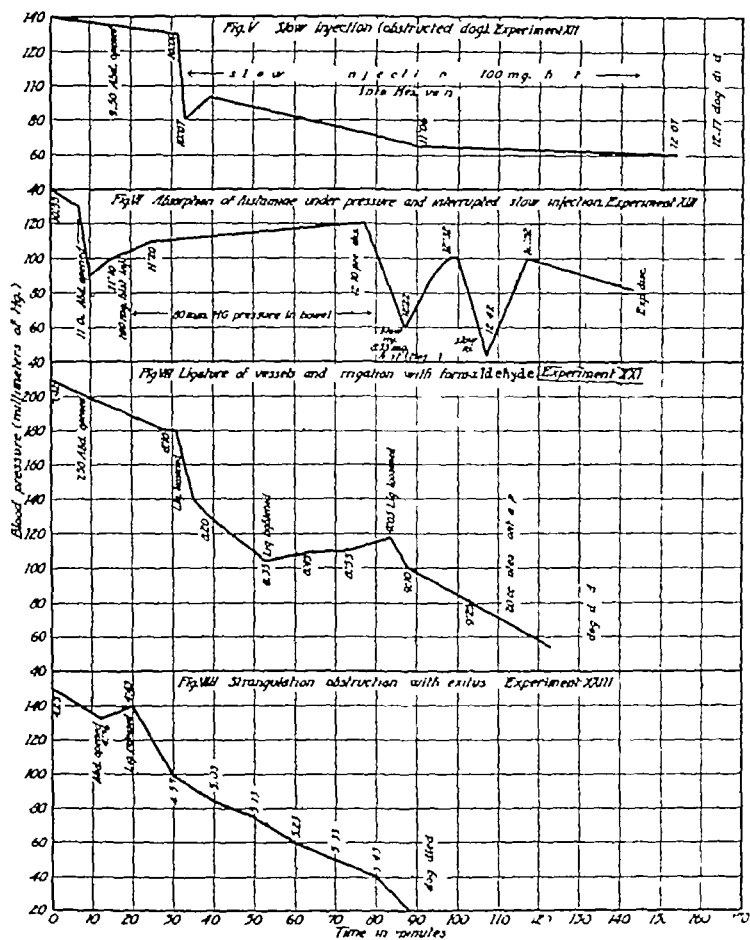


Chart 2—Figure 5, experiment 12 is a blood pressure tracing showing the effect of the slow intravenous injection of histamine in an obstructed dog, figure 6, experiment 13, blood pressure tracing showing the effects of the absorption of histamine placed in the bowel under pressure, and subsequent, slow, interrupted injection of histamine in the mesenteric vein, figure 7, experiment 21, blood pressure tracing showing the effect of ligation of vessels followed by irrigation of the bowels with formaldehyde, and figure 8, experiment 23, blood pressure tracing showing the effect of releasing the ligature which caused the strangulated obstruction.

**Summary**—1 One hour after 100 mg of histamine had been placed in a segment of the normal bowel under a sustained pressure of 80 mm of mercury, there was no fall in pressure. 2 On interruption of the slow injection of histamine into the mesenteric vein, the blood pressure recovered and fell again when the injection was resumed.

histamine in the intestinal content, the intestinal tract itself and in the livers of two guinea-pigs. They fed 100 mg of histamine to a normal guinea-pig, no manifestation of illness was apparent in the animal. A few hours later, when the guinea-pig was killed, only 1.6 mg of histamine was found in the intestinal contents. The alimentary tract itself contained no histamine. In some way, 98.4 mg of histamine had disappeared without causing death or eliciting any great symptoms. In another animal in which the same procedure was carried out, 4.7 mg of histamine remained in the intestinal tract, 4.5 mg had been transported to the liver. According to the authors, if the histamine that was not accounted for had been injected into the portal blood stream, the amount that would have entered the blood per minute would have been more than the dose necessary to kill a guinea-pig after a single intravenous injection. Results of the same nature were obtained when 500 mg of histamine was administered orally to dogs.

Koessler and Hanke<sup>9</sup> also established comparisons between the minimum effective dose of histamine that would lower the blood pressure in the dog when injected into a systemic and into a mesenteric vein. They found the figure for a systemic vein to be 0.0027 mg per minute per kilogram of body weight, 0.006 mg was necessary to cause a decided reduction in the arterial pressure in a mesenteric vein. The increased capillary bed of the liver, Koessler and Hanke stated, is responsible for the increased amount of histamine necessary to effect a reduction in pressure on injection into a mesenteric vein. Dale and Laidlaw,<sup>10</sup> Meakins and Harrington,<sup>11</sup> and Oehme<sup>12</sup> have made observations of the same nature with reference to intravenous injections of histamine into the portal and systemic circulations. This experiment demonstrates that the liver does not have a greatly detoxifying influence for histamine. Koessler and Hanke,<sup>9</sup> therefore, concluded that histamine is rendered pharmacologically inert in passing through the intestinal wall. Just what the fate is of the histamine placed in the normal bowel or the bowel with severed gut obstruction is difficult to state. Some of it probably is absorbed but is detoxified in passing through the wall of the bowel. Koessler and Hanke's<sup>9</sup> failure to find histamine present in any quantity in the intestinal tract or its contents would indicate either that it

9 Koessler, K. K., and Hanke, M. T. Studies on Proteomogenous Amines, The Intestinal Absorption and Detoxication of Histamine in the Mammalian Organism, *J Biol Chem* 59: 889, 1924.  
 10 Dale, H. H., and Laidlaw, P. P. The Physiological Action of  $\beta$  Imminazoly-ethylamine, *J Physiol* 41: 318, 1910-1911.  
 11 Meakins, J., and Harrington, C. R. The Relation of Histamine to Intestinal Intoxication. II. The Absorption of Histamine from the Intestine, *J Pharmacol & Exper Therap* 20: 45, 1922.  
 12 Oehme. Ueber die Wirkungsweise des Histamins, *Arch f exper Path u Pharmac* 72: 76, 1913.

EXPERIMENT 14 (dog 84) —Dec 23, 1926 Aseptic strangulated gut obstruction was established at 11 30 a m by tying a gauze ligature around 4 feet of the ileum and mesentery just snugly enough so that pulsations in the vessels beyond the ligature were not arrested. The dog was allowed to recover from the anesthesia. A tracing was started at 1 55 p m. The arterial pressure was 80 mm of mercury. The abdomen was opened at 2 01 p m at which time the blood pressure was 60 mm. At 2 13 p m it was 60 mm of mercury. Seventy-five milligrams of histamine was injected into the strangulated loop which was already discolored. The blood pressure had dropped to 40 mm of mercury at 2 30 p m. At 2 36, the constriction about the intestine and mesentery was released, and the pressure gradually declined to 30 mm of mercury. At 3 32 p m a few cubic centimeters of the intestinal contents were aspirated from the strangulated loop and injected into a mesenteric vein. Death resulted at 3 40 p m.

*Summary* —Venous strangulation obstruction was established for two and one-half hours. The blood pressure was low at the start, with a gradual decline. Seventy-five milligrams of histamine was placed in the strangulated loop. In thirty-five minutes after the abdomen was opened, the pressure had fallen from 80 to 40 mm of mercury. Constriction about the bowel and the mesentery was then released, with an accelerated fall in pressure.

EXPERIMENT 15 (dog 85) —Dec 27, 1926 Strangulation of the loop was established at the time of operation. A tracing was started at 11 10. The arterial pressure was 170 mm of mercury. The abdomen was opened at 11 17. A loop of the ileum about 4 feet in length was delivered at 11 22. A ligature was tightly placed about the bowel at 11 28, the pressure at this time being 160 mm. At 11 48 the pressure was still the same. The ligature was loosened a little with a just perceptible fall in pressure. At 12 o'clock, the ligature was loosened a little further, with a more definite fall in pressure in two or three minutes. At 12 07 p m, the pressure had dropped to 110 mm of mercury and the ligature was removed with a rather sharp decline in pressure. At 12 14 the pressure had fallen to 80 mm, and the ligature was again tightened. At 12 30, the pressure had risen to 130 mm. At 12 34, the ligature was again loosened, and at 12 45, the pressure had fallen to 118 mm. The ligature on the bowel was alternately tightened and loosened three more times with less reaction following each release of the constriction, but with a gradual decline of the arterial pressure. During the time that the constriction was maintained, the blood pressure was definitely sustained with little rise in pressure, but with each release a gradual fall occurred. The blood pressure at 1 30 p m was 90 mm. At 1 45, 50 mg of histamine was injected into the bowel without an additional fall. At 2 20, the pressure was 64 mm. A few cubic centimeters was aspirated from the strangulated loop into which the histamine had been injected. Death occurred at 2 30 p m.

*Summary* —Strangulation obstruction was established at the time the tracing was made. Twenty minutes later, the constriction was released, accompanied by a fall in pressure. When the ligature was tightened, the pressure rose. Two hours later, histamine was placed in the strangulated loop without an additional fall being noted.

EXPERIMENT 16 (dog 86) —Dec 28, 1927 Strangulation obstruction was established. A tracing was started at 10 50 a m. The blood pressure was 170 mm. The abdomen was opened at 10 57 without any change in the blood pressure. At 11 20, a loop of the ileum 3 feet in length was strangulated, together with its

was almost completely absorbed and rendered innocuous in passing through the intestinal wall, or that it was destroyed within the lumen of the bowel. After histamine had been placed in a normal loop or segment of the bowel that had been obstructed previously, and a few cubic centimeters of the contents from such a loop had been aspirated and injected into a mesenteric vein, we were always able to elicit a decided histamine action after the lapse of an extended interval of time. The reduction in pressure accompanying such an injection was always greater and sustained for a longer time than the occasional reduction following the injection of intestinal contents from other segments in which histamine had not previously been placed. Gerard<sup>5</sup> stated that he was able to isolate 14 mg of histamine from a closed colon loop in a dog eight months after Dragstedt had established the obstruction. In this animal either this amount of histamine remained in the bowel and resisted absorption as well as destruction in the lumen of the bowel, or it had its origin in the intestinal secretion formed by the mucosa of the obstructed segment. Koessler and Hanke<sup>6</sup> granted that their quantitative method for histamine determination in fecal content is only about 60 per cent effective.

Stone and Frior<sup>12</sup> intimated that in occlusion of the bowel, the distention per se, by increasing the intestinal pressure, is a big factor in absorption from the obstructed bowel. When histamine was placed in a segment of the intestine under a measured sustained pressure of 80 mg of mercury, we were unable to detect any evidence of absorption of the histamine.

Meakins and Harington<sup>11</sup> placed histamine (histamine-phosphate) in various segments of the normal intestine in cats. They found that a rather sharp fall of pressure occurred a few seconds after the introduction was made. They stated this fall was more noticeable in the ileum, slightly less so in the duodenum and much less after the introduction of histamine into the stomach or cecum. When the blood pressure was gradually falling, they were unable to accelerate the fall by the introduction of more histamine. They believed that a sudden primary fall in pressure accompanying the introduction of histamine into the bowel should be the rule, and that failure to observe it may be due to the presence of semidigested food in the intestines.

We were never able to confirm this observation in the dog. Failure to depress the blood pressure even more on the introduction of a greater quantity of histamine into the bowel would indicate that no great amount of histamine as such was absorbed and would lend tenuous support to

13 Stone, H. B., and Frior, W. M. Absorption in Intestinal Obstruction, Intra-Intestinal Pressure as a Factor, *Proc South Surg A Abstr J A M A* 84 141 (Jan 10) 1925

mesentery, by being constricted tightly with a gauze tie. At 11 42, the ligature was loosened without causing a definite change in the arterial pressure. At 11 55, the loop was again constricted and loosened at 12 20 p m with a gradual but definite fall of pressure to 140 mm. At 12 42, the ligature was tightened again and loosened at 1 16, following this, there was a slight and gradual fall of pressure to 120 mm. When the loop was constricted again at 1 30, the pressure continued to fall slowly. At 1 45, the pressure was 100 mm. The loop was untied at 1 50 without much effect. At 2 05 p m, 10 mg of histamine was injected with an immediate depression of pressure to 40 mm of mercury, death followed.

*Summary*—Strangulation obstruction was established at operation. Twenty-two minutes later, the constriction was released without a fall in pressure. The ligature was tightened again and loosened after twenty-five minutes, with a definite fall in pressure. An injection of only 10 mg of histamine into a mesenteric vein killed this dog after the ligature had been alternately tightened and loosened over a period of two hours and forty-five minutes.

EXPERIMENT 17 (dog 87)—Dec 28, 1926. Strangulation obstruction was established. A tracing was started at 2 35 p m, the arterial pressure being 180 mm of mercury. The abdomen was opened at 2 40. At 2 55, the blood pressure was 144 mm. At 3 00, the loop of the ileum and its mesentery, about 3 feet in length, were ligated with a gauze tie. At 3 25, the arterial pressure was 164 mm. At 3 30, the constriction about the bowel and the mesentery was released without causing any change. The blood pressure was 160 mm of mercury. At 3 40 another loop of the ileum near the cecum, also about 3 feet in length, and its mesentery, were constricted with a gauze tie. The ligature was released at 4 o'clock, and a slow fall in pressure to 120 mm occurred. At 4 35 the loop was again constricted. The blood pressure was 130 mm of mercury at 4 55. At 5, the ligature was loosened, this was followed by a slow fall of pressure to 118 mm. At 5 05, 5 cc of intestinal contents was aspirated from this loop and injected into a mesenteric vein, causing a fall in blood pressure to 78 mm. At 5 15, another such injection was made. The dog died at 5 30.

*Summary*—Repeated constriction and release of strangulation was accompanied by a slow but gradual fall of arterial pressure.

EXPERIMENT 18 (dog 88)—Dec 29, 1926. Strangulated obstruction of about 5 feet (152 cm) of midileum was established at 11 40 a m by placing a tight gauze tie about the bowel and the mesentery under aseptic technic. The dog was allowed to recover from the anesthesia. A tracing was started at 1 45 p m under ether anesthesia. The blood pressure was 176 mm of mercury. The abdomen was opened at 1 50 and a slight but sharp fall in pressure followed. At 1 55 the pressure was 144 mm, at 2 it had risen to 160 mm. At 2 05, the strangulated loop was delivered with a sharp fall to 124 mm of mercury. At 2 10, the blood pressure had risen to 150 mm. The bowel was a blackish-blue and indurated to touch. The ligature constricting the bowel and the mesentery was loosened with an almost immediate fall in blood pressure to 110 mm of mercury. At 2 20, the ether anesthesia was light, a short convulsive seizure occurred, during which the blood pressure rose to 130 mm of mercury, this was followed by a sharp decline to 84 mm of mercury, above which the pressure never rose again. At 2 35, the arterial pressure was 80 mm and at 2 40, the systolic pressure was 40 mm. At 2 47, the blood pressure was 56 mm, at 3 and at 3 09, 62 mm. The ligature was again tightened about the loop, this was followed by a slight but transient rise in pressure at 3 15 to 76 mm.

the belief that the primary fall in pressure was not occasioned by histamine alone. Unless the blood pressure fell to such an extent that the animal was in a state of shock, the introduction of more histamine into the bowel, if absorbed as such, should depress the blood pressure as did the first injection.

It is generally known that ether anesthesia makes an animal much more susceptible<sup>14</sup> to the effects of histamine. It is stated that an unanesthetized dog can tolerate ten times the amount<sup>15</sup> that an animal under the influence of ether can. Most of our experiments on histamine absorption were made on etherized animals. Failure to elicit the histamine effect by placing it in the lumen of the bowel of these dogs with simple gut obstruction would indicate that no great amount of histamine was absorbed.

The marked fall in blood pressure that accompanies the release of the constricting mechanism in strangulation obstruction demonstrates that autolysis of the intestine deprived of its blood supply progresses rapidly and is accompanied by a rapid liberation of toxic material that gives a histamine-like effect. An effect of this nature was not observed when the kidney or splenic pedicle was clamped off for five hours. It was not seen after ligation of the aorta and vena cava for three hours. The accumulation of carbon dioxide behind the strangulation therefore was not the cause of the fall in pressure when the ligature was released. This fall in pressure seemed greater when there was venous stasis than in the presence of total anemia. This observation is in harmony with the statement of Bayliss<sup>16</sup> that the metabolism in the tissue is increased in the presence of venous stasis. Irrigation of the bowel at the time that the strangulation was established or just before the release of the obstructing mechanism did not prevent the fall in pressure when the ligature was removed. Tightening the ligature again usually brought about a rise of pressure, denoting that the absorption was disturbed. Replacing the removed intestinal contents in the bowel or injecting histamine into the lumen of the strangulated segment did not seem to accelerate the fall.

The only type of tissue in the wall of the bowel that differs materially from that of muscle, kidney or spleen is the mucosa. Depriving the intestine of blood probably occasions an autolysis of the mucosa of the bowel and therefore liberation of a toxic substance. It would seem

14 Cannon, W. B. Traumatic Shock, New York: D. Appleton & Co. 1923, p. 163. Dale, H. H. Report of Shock Committee, Medical Research Committee No. 26, March 14 1919, p. 15.  
15 MacLeod, J. J. R. Physiology and Biochemistry in Modern Medicine, St. Louis, C. V. Mosby Company, 1922, p. 308.  
16 Bayliss, W. M. Principles of General Physiology, New York, Longmans & Company, 1924, p. 422.

Fig 27—Photomicrograph made from the paraffin block shown in figure 25. This is approximately the actual size of the tumor removed at operation. It will be noted that at the top of the section can be seen several lobules of hyperplastic parenchyma which by pressure on the adjacent normal thyroid parenchyma have formed apparent capsules. The lower two thirds of the section is occupied by a large mass or tumor nodule which stains homogeneously pink with eosin and is composed mainly of white fibrous connective tissue cellular detritus and some material that looks like colloid. However, no active thyroid tissue can be seen. Reduced from an enlargement to twice the normal size.







Fig 28 —Higher magnification of figure 27 to show and compare the constituents of the large tumor mass, the small nodule of hyperplastic tissue and the compressed normal thyroid parenchyma. It is obvious that the main tumor mass in this specimen was without function, as there is nothing but inert material constituting this tumor and that the active portion of the gland and that region responsible for the hyperactivity of the thyroid is located in the upper portion or in the region showing the hypertrophy and hyperplasia. The sharp localization of this hyperactive tissue in the otherwise normal parenchyma is striking. The main tumor mass does not suggest a neoplasm, but on the other hand atrophic degenerated parenchyma resulting from previous hyperinvolution and probably involution of a once hyperactive parenchyma. It is, of course, plain that enucleation of this inert mass would not have cured the patient and that this tumor per se probably played no role in the production of the clinical syndrome but was a coal of a fire that has burned, or an area of extreme hyperinvolution. Reduced from an enlargement to four times the normal size.

that a damaged mucosa would be more permeable than the normal one to absorption from the lumen of the bowel. In these experiments, however, it would appear that autolysis of the wall of the bowel rather than an increased absorption from the lumen occasioned the depression of blood pressure.

Meakins and Harington<sup>11</sup> damaged the mucous membrane of the intestine by tying off the arterial supply of the part under investigation and then injected histamine. When the blood supply was arrested in this manner for from five to fifteen minutes and histamine was placed in the bowel, a marked primary fall was observed, but there was not a tendency toward a gradual and continued decline. This occurrence, the authors felt, indicated that the absorption of histamine took place rapidly and then almost ceased. Our observations would indicate that it was injury to the mucosa itself rather than absorption from the lumen that brought about the fall in pressure. We do not, of course, deny that absorption is not increased over that from the normal bowel or the segmentally obstructed bowel. As previously indicated this was our assumption, but the fall in pressure in the irrigated strangulated loop and the failure of the injected histamine to accelerate the drop in pressure would not support such a contention.

In the strangulations of short duration, only transient and slight reductions in blood pressure were observed when the constriction was released. In some instances, a fall in the pressure was not obtained. In the strangulations established a few hours previously, the fall in pressure was constant when the strangulation was released. In one animal (experiment 23, fig 8), the blood pressure gradually declined, and the dog died as a result of this alone, although the pressure had been good before the constriction was released. In a few animals with strangulation obstruction, the pressure was low when the tracings were begun. In these animals it would appear that the visceral peritoneum of the strangulated intestine had become permeable to the toxic substance liberated by the damaged mucous membrane, and that absorption was occurring through the peritoneal cavity. For how otherwise could absorption occur with the lymphatics and mesenteric vessels obstructed?

It would also appear that when the blood supply to a segment of the bowel is disturbed by increasing the tension within the lumen a similar fall in pressure should be noted. Van Zwahlenburg<sup>17</sup> has examined vessels of the intestinal wall with a cystoscope in the lumen of the bowel and has found that states of venous and arterial anemia may be produced by increasing the distention in the loop. The distention ulcer, however, observed so frequently on the antimesenteric border of the

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<sup>17</sup> Van Zwahlenburg, C. Strangulation Resulting from Distention of Hollow Viscera, *Ann Surg* 46:780 1907.

dose of thyroid extract was increased, a return to the normal rate and a more stable metabolism was noted. This was accompanied by an amelioration of the symptoms.

*Juvenile Rheumatism*—From a statistical study of the incidence of rheumatic fever in children in London, Benjamin<sup>24</sup> concluded that it is a disease of poor people and that the incidence of the disease is in direct relation to the degree of the poverty.

Miller<sup>25</sup> made a comparison between the reports of the British Medical Association and those of the Medical Research Council on arthritis, and drew the following conclusions in regard to the importance of six supposed etiologic factors. 1 Influence of social status. They agreed that it is a disease of the poor, but not necessarily of the poorest. 2 The influence of heredity. It was agreed that heredity is of no influence. 3 The influence of school environment. The home rather than the school is the causative factor, as those children who were taken from homes in the "rheumatic stratum" and placed in special schools escaped. 4 The influence of tonsillar disease and tonsillectomy. Diseased throats were found in from 75 to 83 per cent of the patients. The removal of the tonsils does not prevent chorea. 5 The influence of contagion. Contagion is, at most, of the slightest importance. 6 The influence of damp dwellings. "There is nothing in the theory of damp houses as a causative factor."

*Incidence of Hypertrophic Arthritis*—Garvin<sup>26</sup> made an investigation of the incidence of hypertrophic arthritis of the spine in a series of 2,090 patients more than 50 years of age, who, without complaint of symptoms in the back but because of suspected urinary disorders, were subjected to roentgenologic examination of the kidneys, bladder and ureters during 1925. What Garvin designated as "incidental hypertrophic arthritis of the spine" was found in 40 per cent of the women and in 67 per cent of the men. Garvin discussed the possible etiologic factors, such as abscessed teeth, infected tonsils, etc., the presence of a traumatic factor, such as obesity, in which the assumption of chronic trauma can be made and also the evidences of senescence. He stated that in view of the high incidence in persons beyond 50 years of age, especially in men, of hypertrophic arthritis of the spine, unaccompanied by any symptoms in the majority of the patients, the condition should be considered and treated conservatively. He pointed out the obvious improbability of any single accident or injury being responsible for the development of hypertrophic arthritis.

*Hypertrophic Arthritis of the Cervical Spine*—Forrester<sup>27</sup> described various thickenings noted on the transverse processes of the cervical

24 Benjamin, F. J. Lancet 1-1175 (June 4) 1927  
 25 Miller, Reginald. Brit. M. J. 1 952 (May 28) 1927  
 26 Garvin, J. D. Hypertrophic Arthritis of Spine, Arch. Surg. 15 118 (July) 1927  
 27 Forrester, Henri. Lancet 2 65 (July 9) 1927

dog with an obstructed intestinal loop (both ends turned in) and in the patient with strangulation obstruction, is rarely seen in the patient with simple intestinal obstruction. We have never seen it in a large number of dogs in which simple obstruction of the gut has been established. The damage to the wall of the bowel in simple obstruction in which the intralumen tension is increased rarely approximates that observed in strangulation obstruction.

#### CONCLUSIONS

1 Absorption of histamine from the normal small intestine (duodenal and ileum, of the dog and in simple obstruction of the small intestine of two days' standing cannot be detected by the physiologic test for histamine.

2 In strangulation obstruction, a great fall in arterial blood pressure occurs following the release of the strangulating mechanism.

3 The autolysis of intestinal mucosa deprived of its blood supply is rapid and is accompanied by the liberation of a toxic substance that gives an effect like that of histamine.

4 The absorption of histamine from the lumen of a strangulated segment that is still viable does not appear to be great.

vertebrae in patients suffering from chronic arthritis. He expressed the opinion that these thickenings frequently give rise to occipital headaches and neuralgic pains radiating down the arms. That osteo-arthritis of the cervical spine may cause serious pressure on the nerve roots, was pointed out by Hendry and Fowler.<sup>28</sup> They examined a patient who showed marked muscular weakness and sensory disturbance of one arm, without pain, in whom the symptoms were ascribable only to this cause.

#### TUBERCULOSIS

*Remote Results of Operative and Nonoperative Treatment for Tuberculosis of the Ankle in Children*—Pouzet<sup>29</sup> made an investigation of the results of treatment, both nonoperative and operative, in children with tuberculosis of the tibiotarsal articulation in Nové-Josserrand's clinic at Lyon. The statistics cover a group of 104 patients, all children under the age of 16, who were treated between 1898 and 1922, inclusive. The minimum period of observation was three years. The study was limited to those cases in which the primary focus of disease had been in the tibio-astagalar articulation, with or without secondary invasion of other bones or joints, and did not include those with diffuse lesions starting simultaneously in all the tarsal bones. It has been the general policy in the clinic to employ immobilization as the best method of treatment, except in rare cases in which the severity of the process or the presence of a complication made surgical intervention necessary. The parts were encased in plaster, and the castings changed at intervals of three months. Open air, sunlight, and other antituberculous measures were also employed. When the tuberculous process appeared to extend, or when progress seemed to be uncertain, surgical intervention was resorted to. The results were graded as normal—meaning absence of functional impairment, very good—excellent function, but with minor troubles, such as limp when tired, good—slight limp, with walking capacity exceeding 10 kilometers, fairly good—limp, with walking capacity of from 5 to 10 kilometers, and bad.

The results in general in a total of 104 patients, of whom ninety-one were treated by immobilization, were as follows. Cure was obtained in sixty cases, or 66 per cent, in eighteen the feet were normal, in twenty-eight the results were very good, and in fourteen the results were good or fairly good. (Four of these patients died later, after the local lesions had healed.) Failure resulted in thirty-one cases, or 34 per cent. Four patients died during treatment, twenty-seven required operative intervention, twenty because of extension and seven because of recurrence.

28 Hendry, A W, and Fowler, Andrew. *Lancet* 1 1181 (June 4) 1927.  
29 Pouzet, F. *Rev d'orthop* 14 99, 1927.

# THIRTY-FIFTH REPORT OF PROGRESS IN ORTHOPEDIC SURGERY\*

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MURRAY S DANFORTH, M D

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HALLE, GERMANY

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ANTWERP, BELGIUM

## CONGENITAL DEFORMITIES

*Congenital Dislocation of Knee*—Spiers<sup>1</sup> reported four cases of congenital luxation of the knee. Of these, three were cases of double luxation and one of single luxation. In all cases the tibia and fibula were displaced forward, upward, and laterally. Only the patient with the single dislocation was treated by the author. Manipulative reduction was performed under an anesthetic and the deformity corrected, the knee being immobilized in plaster in a position of from 35 to 40 degrees flexion. Satisfactory progress was reported at the end of six weeks, when the patient was last observed.

*Congenital Torticollis*—From a study of thirty-seven patients with wry neck observed at Spitzky's Clinic in Vienna during the last two years, Aberle<sup>2</sup> has drawn the following conclusions. Congenital wry neck is to be considered as "vitium primae formationis." It is found in association with other congenital deformities and may be present in several members of the same family. The patients may be classified in three groups: (1) patients with oblique posture of the head and asymmetry but without discoverable changes in the sternomastoid muscle, (2) patients with marked changes in one of the sternomastoid muscles, but without evidence that the muscle was injured at birth, and (3) patients with injury of one of the sternomastoid muscles superimposed on a prenatal degeneration of the muscle. The author agrees that an

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\* This Report of Progress is based on a review of 196 articles selected from 429 titles dealing with orthopedic surgery appearing in medical literature between July 2, 1927, and Sept 24, 1927. Only those papers which seem to represent progress have been selected for note and comment.

1 Spiers H W. J Bone & Joint Surg 9 469 (July) 1927

2 Aberle W. Ztschr f orthop Chir 49 27 1927

Just as good results were obtained in the cases in which sinuses were present as in those in which they were not. The younger the patients the better were the results. The severity of the disease seemed to increase with age, and the older the patients the higher the number of deaths and the greater the necessity for resorting to operative treatment. The cures were fairly permanent, with recurrence in only 3.5 per cent of the patients. The author does not consider ankylosis the best result, but, on the contrary, stated that a certain degree of mobility helps in walking, without apparently increasing the risk of recurrence. Roentgen-ray examination showed a perfectly normal foot in a few cases, in others, lesions limited to the articular surfaces, such as irregularity of the joint space, exostoses and osteophytes, fibrous and bony ankylosis, and flattening of the astragalus. Hypermobility developed in the uninvolved joints to compensate for stiffness in the diseased joints. The diseased foot showed retardation of growth, and was always shorter than the normal one. In a few cases there was a shortening of the tibia of from 1 to 3 cm. No deformities of the foot were noted except pes cavus in three instances.

The patients in whom conservative treatment failed (thirty-nine of 104) and operative measures had to be employed also were studied. The cases were classified as follows: twenty-five late interventions after immobilization was tried, eighteen because of aggravation, and seven because of early recurrence, fourteen early interventions necessitated by the extent and severity of the process. The operations consisted in astragalectomy and localized tarsectomy. In the beginning, the proportion of astragalectomies was high, but as the efficacy of more conservative procedures was demonstrated, the number of astragalectomies decreased. Bony lesions were noted in the astragalus thirty-nine times, in the tibia twenty, in the calcaneum twenty-five, in the scaphoid two, and in the cuboid five. The average period required for a cure with complete healing of sinuses and the possibility of walking was about eleven months after astragalectomy and thirteen months after tarsectomy. Of the thirty-nine patients, cures were obtained in twenty-eight, or 73 per cent, on one amputation was performed, and one is still under treatment. There were nine deaths, or 23 per cent. The fatalities occurred chiefly in young patients and were due to the severity of the process rather than the result of the interventions. From a study of the results the author concluded that operative treatment is capable of preserving a useful foot in a large number of patients with tuberculosis of the posterior tarsus. Although the results of the two methods cannot be compared because of the difference between the disease processes in the two groups, Pouzet stated his belief that treatment by immobilization should be tried in children, and that only after a thorough trial without improvement, or in the case of a severe lesion, should surgical intervention be employed.

injury to a normal sternomastoid muscle may be followed by the formation of an hematoma, but expressed the opinion that this heals in a short time and is not necessarily followed by wry neck. The asymmetry of the head and face associated with congenital wry neck is not hemiatrophy but the general reaction of the bone to pressure, with resulting hindrance of growth. The asymmetrical development tends to increase but may be arrested by early operative correction of the deformity.

[ED NOTE—Aberle's theory that injury of the sternomastoid muscle, sustained at birth, is not sufficient to account for congenital torticollis is interesting, but the evidence he has adduced is insufficient to prove his contention.]

*Congenital Radio-Ulnar Synostosis*—Pepi<sup>3</sup> wrote on the subject of congenital radio-ulnar synostosis at the upper ends of the radius and ulna, and expressed the belief that the best method of restoring pronation and supination is the operation described by Galeazzi. This consists of a transverse osteotomy of the radius at a level a little above the insertion of the pronator radii teres, with the removal of a section of the bone, and the production of a pseudarthrosis at this point.

[ED NOTE—Authors who have made a study of congenital radio-ulnar synostosis have stated that excision of the head and neck of the radius usually fails to restore the rotary movements of the forearm. The synostosis usually recurs. Galeazzi's operation has advantages in this respect, as it is performed at a distance from the synostosis.]

#### ENDOCRINE DISORDERS AND THERAPY

*Acromegaly*—In the annual oration delivered before the London Medical Society, Cushing<sup>4</sup> summarized the present knowledge of the function of the hypophysis. H. M. Evans is credited with the discovery that anterior lobe extracts would stimulate growth. It is difficult to obtain an active extract, and great variation is found in the commercial products. Experiments with the extracts have not produced acromegaly, but gigantism. Gigantism is probably the result of a process which has started before the epiphyses have become ossified, whereas acromegaly is an expression of the same influence acting after epiphysal growth has ceased. Cushing classified the pituitary syndromes as follows:

*A. Hypopituitarism*—Absolute privation of hypophysis probably leads through cachexia to death.

*B. Hypopituitarism*—1. Anterior lobe deficiency due to ischemic necrosis (Simmonds's disease). Simmonds reported thirteen cases of destruction, partial or complete, of the anterior lobe, many by septic infarcts. The counterpart of dwarfed animals thus exists in the dwarfed persons and results from disturbance of hypophysis in early life.

3 Pepi, C. *Policlinico* 34:205 (May 15) 1927.

4 Cushing, Harvey. *Brit M J* 2:1 (July 2) 1927.



[Ed. Note—We wish to call attention to the fact that when patients with supposed tuberculosis of the joints are treated nonoperatively, it is always difficult to be certain of the diagnosis.]

#### POLIOMYELITIS

In a recent editorial in the *Journal of the American Medical Association*,<sup>30</sup> the knowledge of infantile paralysis has been well summarized. Cases of poliomyelitis have been divided into three classes: (1) those with characteristic paralysis, (2) those without paralysis, but exhibiting symptoms indicative of meningeal irritation and usually minor disturbances of the motor centers, the so-called abortive type, and (3) those showing symptoms similar to the initial symptoms of known cases of infantile paralysis, but without definite indications of involvement of the central nervous system. In discussing the treatment it has been stated that there is every reason to believe that rough handling of the spine and manipulation, as practiced by chiropractors and members of other cults, renders impossible the recovery which might otherwise take place in some of the affected nerves. The author considers that the only effective method of prevention is complete isolation from contact with patients in all stages of the disease, including convalescents and carriers. It has been recommended that during an epidemic until cold weather sets in children should not travel about any more than is absolutely necessary. No specific prophylactic treatment that can be applied practically has yet been discovered.

We have noted a recent report by the Council on Pharmacy and Chemistry of the American Medical Association<sup>31</sup> of its refusal to accept for inclusion in New and Nonofficial Remedies poliomyelitis antistreptococcus serum. This action was based on the following objections: 1. The organism from which the serum is produced is not generally accepted as the etiologic agent of poliomyelitis. 2. The published reports on the serum are generally favorable, but there is considerable question as to whether the groups of control cases are directly comparable. 3. It has been found that on account of widespread favorable newspaper publicity given the serum, the physician often feels compelled to use it, though he is not convinced of its efficacy. Indeed, laymen often demand its employment. In our estimation, the Council has taken the proper stand in refusing to accept any poliomyelitis antistreptococcus serum until more positive evidence for its usefulness becomes available.

#### PYOGENIC INFECTIONS

*Ostomyelitis*—In discussing infections of the bones and joints in children, Stone<sup>32</sup> pointed out that while epiphyseal separation is a ill

30 Infantile Paralysis, Editorial, J. A. M. A. 89 1662 (Sept. 24), 1927.  
31 Poliomyelitis Antistreptococcus Serum Reports of Council on Pharmacy and Chemistry, J. A. M. A. 90 617 (Feb. 25), 1928.  
32 Stone, J. S. Boston M. & S. 1 197 367 (Sept. 29), 1927.

2 Deficiency syndromes due to compression of parhypophyseal tumors (Frohlich's disease) This syndrome is less cleancut than Simmond's disease, because of the different parts of the gland and of the adjacent structures that may be involved, particularly the hypothalamus. The patients are mentally alert, but show extreme degrees of adiposity or emaciation, polyuria or the reverse, dwarfism, sexual infantilism, or premature physical senility. Cushing has encountered in all, eighty-one verified examples of these parhypophyseal tumors. 3 Hypopituitary states associated with chromophobe adenomas. Of all pituitary syndromes these are most often encountered. Cushing had 188 in his series. They occur almost exclusively in adult life. The disorder is common, as common, in all probability, as goiter. One cannot diagnose this condition without definite local evidences of the growth. Changes almost always occur in adult life and are limited to the tendency to adiposity, loss of hair, sexual dystrophy, etc. It is not unusual for this condition to be treated as myxedema. Ordinarily the sella is greatly distended.

C Dyspituitarism. This is a mixed group of syndromes in which hyperpituitary symptoms have been superseded by the reverse state.

D Hyperpituitarism. 1 Gigantism—Gigantism is due to chromophile adenomas originating in preadolescence. Cushing has seen sixty-five patients with such tumors. They are much oftener found in adults, hence acromegaly is much commoner. 2 Acromegaly—*acromegalia* adenomas of adult life. Acromegaly calls attention to itself before the adenoma has reached the tumefaction stage. Cushing feels justified, in view of the low mortality (41 per cent), in attacking the tumors early while the sella was still small. He noted as postoperative results (1) loss in weight, (2) lowered metabolic rate, and (3) relative intolerance to carbohydrates. By partial hypophysectomy the intolerance may be reduced and existent glycosuria checked. Complete extirpation is to be avoided lest diabetes insipidus, excessive adiposity, and even a fatal cachexia supervene. Only when substitution therapy has been made practical will this risk be overcome.

Davidoff and Cushing<sup>5</sup> stated their belief that acromegaly represents a state of hyperpituitarism of the acidophil cells of the pars anterior. They consider that there are ample reasons in support of the view that the meliturias which occur in 25 per cent of all cases of acromegaly are primarily hypophyseal, even though the pancreatic islets play a secondary rôle in their production.

In seven patients with acromegaly (four women and three men), Castex and Schteingart<sup>6</sup> found the basal metabolism increased in three

5 Davidoff, L. M., and Cushing, Harvey. Studies in Acromegaly, *Arch. Int. Med.* 39: 751 (June) 1927.

6 Castex, M. R., and Schteingart, M. *Rev. Soc. de med. int. y fisiol.* 3: 66, 1927.

recognized, the frequency with which an epiphysis may be loosened without actually being displaced is not generally appreciated. Similarly, subperiosteal and greenstick fractures are seen more often in children because of the relatively greater thickness of the periosteum. The importance of these and other mild injuries in relation to infection lies, according to the author, in the fact that areas of increased susceptibility to infection are produced in the regions of the epiphyses by the trauma. Bocchini<sup>33</sup> also has been convinced from a study of the literature that trauma plays an important part in providing an area of lowered resistance in the bone to infection. Discussing acute osteomyelitis of the spine, he stated that the vertebral body is involved more commonly than the neural arch. If the body is involved the prognosis is grave, if the neural arch is involved it is less grave. Of the neural arch the author has found the lamina more often affected, but either the spinous process or the transverse process may be affected. When the involved area of the spine is accessible he has recommended surgical intervention.

*Control of Wound Infection*—Orr<sup>34</sup> pointed out the necessity of following three fundamental rules in the treatment of infected wounds (1) a thorough primary operation, aseptically performed, (2) the avoidance of secondary infection in the postoperative dressings, and (3) immobilization, in correct position, of all injured parts until healing has been established. He advocated packing the wounds with gauze on which petrolatum has been smeared, and fixation of the parts in plaster at the time of operation. By this method he considers it unnecessary to change the dressings more often than at intervals of from three to four weeks, and not infrequently the infected bone cavities heal completely with only one or two dressings.

[ED. NOTE—Approaching this method with grave doubts as to its safety and recognizing its possible dangers unless the patients are carefully watched, we have been able to confirm Orr's claims in a small group of cases. We agree that the thoroughness of the operation is of prime importance and that unnecessary postoperative dressings are to be avoided. Whatever other arguments may be advanced in support of this method, the humanitarian one of reducing painful dressings to a minimum, especially in children, is a powerful one.]

#### VASCULAR DISEASES

*Thrombo-Angiitis Obliterans*—Lian, Puech and Viau<sup>35</sup> made an investigation of fifty-two patients with endarteritis obliterans, with the purpose of shedding some light on the etiology of the disease. Dis-

33 Bocchini, A. *Pediatrics* 35:554 (May 15) 1927.  
 34 Orr, H. W. *Minnesota Med* 10:362 (June) 1927.  
 35 Lian, Puech and Viau. *Bull et mem Soc med d hôp de Paris* 51:534 (May 5) 1927.

and normal in four. The largest increase was 31 per cent. They concluded from their studies that simple acromegaly without change in the tubers or in the posterior lobe of the pituitary causes an increase in metabolism. The complicated type of acromegaly does not produce this effect.

*Parathyroid Hormone and Calcification of Fracture Callus*—Lehman and Cole<sup>7</sup> conducted some experiments on animals to determine the effect of injections of parathyroid extract on the calcification of fracture callus. *A priori* they did not believe that the extract would hasten or aid in inducing the deposit of callus, because its action is to mobilize the fixed calcium in the body, and as Hunter and Aub have shown, the excess of calcium in the blood serum of patients who have had parathyroid extract comes largely from the bones. The results of the experiments show that parathyroid extract does not hasten the calcification of fracture callus. The only effect noted in rats is a tendency to delay the process.

On the other hand, Hueper<sup>8</sup> performed some experiments which led him to draw the opposite conclusion. He stated that repeated injections of parathyroid extract apparently stimulate the production and calcification of osteal tissue. However, the extract cannot be used without danger, as evidenced by the finding of areas of necrosis in the myocardium and the cortex of the suprarenal gland in animals which have received repeated injections of it.

[ED NOTE—The work of Hunter and Aub clearly demonstrates that continued administration of parathyroid extract causes increased elimination of calcium from the body and in time leads to decalcification of the bones.]

#### DEVELOPMENTAL DISEASES

*Osteochondritis Ischiopubica*—Attention has been called by Wuelfing<sup>9</sup> to a condition which he has named osteochondritis ischiopubica. The clinical picture resembles that of hip disease, although the symptoms are less severe. The condition consists of a disturbance of the ossification of the cartilage at the point of junction of the ischium and pubis in the acetabulum. An appearance of haziness and globular thickening develops. According to the author, the condition should be suspected when a patient complains of an indistinct disturbance of the gait, though on roentgen-ray examination the femoral head and the hip joint appear normal.

7 Lehman, E. P., and Cole, W. H. Parathyroid Hormone and Calcification of Fracture Callus, *J. A. M. A.* **89** 587 (Aug. 30) 1927.

8 Hueper, W. Effect of Repeated Injections of Parathyroid Extraction on Calcification of Osteoid Tissues, *Arch. Path.* **3** 1002 (June) 1927.

9 Wuelfing, M. *Deutsche Ztschr. f. Chir.* **199** 413 1926.

cussing probable causes, they stated that acute or chronic infection or acute-intoxication, as in diabetes or gout, may be factors in rare cases. Nutritional diseases occurring about the age of 50 probably play an important part. Tobacco occupies a considerable rôle, while that of syphilis is insignificant. The writers do not regard Buerger's disease as a pathologic entity, but merely as a clinical form of endarteritis obliterans occurring with greatest frequency among the Jews of Central Europe.

Guillaumie<sup>30</sup> has made a study of the pathologic lesions in Buerger's disease, employing serial sections covering the entire length of the diseased arteries. As a result of his examinations he does not agree with Buerger's views, namely, that thrombosis constitutes the primary feature of the disease, with secondary parietal changes affecting the vessel walls. Guillaumie expressed the opinion that the primary lesion is a proliferating endarteritis which obliterates the lumen of the vessel and leads to thrombosis in the blind culdesac of the artery above that point.

*The Operation of Embolectomy in Embolic Disturbances of the Extremities*—Key<sup>31</sup> has performed the operation of embolectomy on ninety-five patients and is convinced of its value. In discussing his experience, he stated that the embolus is usually found at the point of division of an artery, and that if it does not at first completely occlude the vessel it quickly grows (from a few hours to several days) until it shuts off the blood supply entirely. To determine the seat of the embolus is difficult. Usually it is considerably higher than the region of circulatory disturbance. Palpation of the arterial pulsation may indicate the point of lodgment, but often the pulse is weak as a result of the weak heart. The diagnosis is easy when the embolus causes primary occlusion of the artery, but when the occlusion is only partial, it is much more difficult. Key found great advantage in local anesthesia, and advises that the operation be performed with this aid. He followed the technique of Carrell, using fine needles and sutures of silk sterilized in petrolatum. Gauze moistened with a 2 per cent solution of sodium citrate is used, and the instruments and gloves are rinsed in the same solution. The artery, after being compressed with a soft clamp, is opened somewhat above the point of suspected lodgment of the embolus. By careful traction even long emboli may be removed, but sometimes it is necessary to make a second opening in the vessel. When the embolus does not slip out easily, one must try to strip or massage it upward from below. The prognosis depends on the time elapsed between the lodgment of the embolus and its removal, the situation of the embolus and the general condition of the patient, especially the heart.

<sup>30</sup> Guillaumie, A. C. Bull et mem. Soc. med. d'hop. de Paris 51 611 (May 12) 1927.  
<sup>31</sup> Key, Einar. Zentralbl. f. Chir. 51 2190 (Aug. 27) 1927.

*Osgood-Schlatter's Disease in Adults*—Opposing the opinion of other authors, Brandes<sup>10</sup> stated that Osgood-Schlatter's disease of the tibial tubercle occurs not only in young growing persons, but also in adults. He cited as an example the case of a man, aged 48, who showed the characteristic clinical signs and typical roentgenologic appearance. The symptoms dated from a strain received during the war. The examination showed that the apophyseal lines of the tibial tubercles of both knees had failed to ossify during the years of growth and had persisted as points of reduced resistance to strain. Brandes stated that he has seen a number of examples of the same condition in young adults of about 20 years. In the patients with only mild symptoms he usually found conservative treatment sufficient, but when the condition was persistent he employed operative treatment. The operation consisted in splitting the patellar tendon, exposing the tubercle, and removing the affected area with the curet.

[ED. NOTE—While symptoms may not arise until adult life, we do not believe that Brandes meant to infer that the condition originates then. The main fact is that Osgood-Schlatter's disease may go on in youth to complete failure of union between the apophysis of the tubercle and the tibia, and that the fibrous connection may yield to strain in later years. One of us has encountered this condition in young adults, and at operation found the tubercle entirely loose. Removal relieved the symptoms.]

*Vertebral Epiphysitis*—Zur Verth<sup>11</sup> has encountered in children a developmental disease of the spine that evidently corresponds to what other authors have described as vertebral osteochondritis. He found the condition limited to a single vertebra. In the early stage there is an appearance of marked atrophy of the vertebral body, with an irregular zone in the middle. In the later stage the body appears to diminish to a narrow plate which represents the central dense zone, while the adjacent areas disappear. The symptoms may resemble those of Pott's disease, but the author felt that he could exclude the possibility of tuberculosis, typhoid fever, syphilis, or trauma. He considers the condition to be related to Koehler's disease of the scaphoid and to other similar diseases, and proposes the name "vertebra plana."

*Clinical Importance of the Os Tibiale Externum or Accessory Tarsal Scaphoid*—Calling attention to the clinical importance of the os tibiale externum or accessory scaphoid, Sever<sup>12</sup> stated that this condition may be of medicolegal significance, especially following trauma, because of the possibility of its being mistaken for a fracture. It is generally associated with badly pronated and relaxed feet which are particularly

10 Brandes, M. *München med Wchnschr* 74 1830, 1927.

11 Zur Verth. *Ztschr f orthop Chir* 48 70, 1927.

12 Sever, J. W. *Clinical Importance of Os Tibiale Externum or Accessory Tarsal Scaphoid*, J. A. M. A. 89 359 (July 30) 1927.

*Treatment of Spastic Paraplegia by Sympathetic Ramisection—* Royle<sup>38</sup> reaffirmed his original opinion of the value of ramisection and described the late results of the operations he performed some years ago. Detending his experimental work, he wrote that "although a number of investigators have failed to verify my results, no one has attempted to reproduce them on the goat, the animal which I used." In the article, he repeated the story of his first operation on a patient, Sept 1, 1923. The improvement in this patient persists to date, three years after operation. Besides changes in tone, he enumerated the following results: increased temperature, improvement in muscular control, improvement in balance, disappearance of tremor, and increase in the size and strength of the limb. Coming to the subject of congenital spastic paraplegia, he noted two main types: (1) the rigid type and (2) the choreic type. In the first group he distinguished (a) cases in which the patient retained or had developed muscular control, (b) cases in which voluntary control was not present. He performed ramisection in twenty-six patients with spastic paraplegia of both lower limbs. All were of the rigid type except one of the choreic type. He analyzed his results as follows: Walking. There was diminution in disability in all but one patient. Before operation sixteen of twenty-six could not walk alone. Fourteen of these patients learned to walk within six months after operation. Changes in Tone. Rigidity invariably diminished and a wider range of movement developed. Balance. Increased facility in balance was an invariable postoperative result. Performance of Active Movements. "Almost every patient reported increased facility in performing active movements." Speed was always increased. Inhibition. Improved inhibition was a consistent result when the tone was great enough to impede normal movement. Changes in Condition of the Viscera. Seventeen of the patients were suffering from chronic constipation. Thirteen of this number "were more or less relieved." Vasomotor Changes. Every patient in the series exhibited postoperative vasomotor changes. The acute changes were transitory, but a definite increase in temperature and freedom from vasomotor disorder persisted after ramisection. In respect to structural changes such as contractures, the author stated that these must be dealt with surgically before the full effect of ramisection is apparent. In one patient who showed choreiform movements, improvement in function was definite and there was a lessening of the movements.

38 Royle, N. D. *M. J. Australia* 1 632 (April 30) 1927

(To be continued)

resistant to corrective treatment. He has reached the point of view that in such cases when the feet are persistently painful, operative treatment is necessary. The operation consists of an arthrodesis of the astragalo-scaphoid joint, with removal of the accessory scaphoid and shortening of the tendon of the tibialis posterior muscle.

## NUTRITIONAL DISEASES

The chemical changes found in rickets have been discussed by Gamble,<sup>13</sup> who pointed out that the disease depends on a reduction, not only of the calcium in the blood plasma, but also of phosphorus. Since the calcium content is nearly stationary in ordinary rickets, the measurement of the phosphorus content of the blood plasma gives the degree of rickets. In tetany the blood calcium is materially lowered. The dietary studies have shown that an unknown substance "D" is necessary to keep the calcium and phosphorus balance up to normal. The same effect is produced by sunlight. This substance "D" is present in abundance in cod liver oil. He pointed out that from a practical point of view the important result of the recent studies of rickets has been the recognition of the curative action of cod liver oil and sunlight.

Hess<sup>24</sup> found that cholesterol when irradiated with ultraviolet light possesses antirachitic properties and that brain which contains a large amount of this substance may be used successfully. Ergosterol prepared from yeast is the only stereo found which acquires antirachitic activity on exposure. He stated that irradiated yeast may be used and also irradiated dried milk, the milk being the most successful.

[illegible][illegible]



## MÉNIÈRE'S DISEASE

ITS DIAGNOSIS AND A METHOD OF TREATMENT \*

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BALTIMORE

The purpose of this communication is to present the results of an operation which I believe will permanently cure the symptoms of Ménière's disease. Briefly stated, the treatment is section of the auditory nerve intracranially. It is attended with almost no risk of life, and since there is always subtotal deafness on the affected side before the operation, section of the nerve adds little of practical importance to the deafness. Other symptoms do not result when the auditory nerve is severed.

In its usual form, Ménière's disease has a well defined and well recognized symptom complex. The patient is suddenly seized with a violent attack of dizziness, at once associated with nausea, vomiting and unilateral tinnitus referred to an ear which is progressively growing deaf. These attacks are repeated from time to time, usually with increasing frequency. The patients are well between the attacks, though eventually they may recur so frequently as to be almost continuous. At such times as to complain in case 1, the patient for weeks may not be able to take food or to retain it when it is taken. The attacks are of such violence and come on with such suddenness that the patient lives in terror of their reappearance. They last from a few hours to several weeks. The symptoms have been known and described for more than a century, but it was Ménière who first suspected their aural origin. Whether or not his impression proves to be correct he at least rescued a clinical entity from a hopeless confusion of symptoms which had not implied any pathologic significance. At the time of Ménière's publication the symptoms of this condition, and of epilepsy also were considered evidence of cerebral congestion or apoplexy. Indeed the sudden nature of the attacks of Ménière's disease might well appear at first glance to be apoplectic.

It is necessary to understand the beliefs current at that time in order not to be misled by the title of Ménière's paper, 'Maladies de l'oreille interne offrant les symptômes de la congestion cérébrale apoplectiforme.' There is even yet the erroneous impression (perhaps attributable to the

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Brockman<sup>16</sup> also reported his observations on three patients with the same condition. There was the same association of late developing bone deformities with chronic nephritis. He was able to obtain at autopsy a tibia and fibula from one of the patients for pathologic examination. The chief descriptive points obtained from this study are as follows: 1. The shafts of the bones in renal rickets are straight, and the deformities are due to separation and displacement of the epiphyses. (It is not desirable to correct the deformities because of the danger of uremia and the tendency to recurrence.) 2. The red marrow is replaced by fat marrow. 3. There is little bone formation. 4. Active bone absorption by osteoclasts takes place in the neighborhood of the growth disks and also of the shaft. 5. The absorbed bone is replaced by fibrous tissue. 6. The walls of the arteries in the medulla are thickened. 7. An increase in the number of capillaries is observed in the region of the growth disk.

*Osteitis Deformans*—Van Hazet and Andrews<sup>17</sup> made a study of osteitis deformans, or Paget's disease, with careful chemical and laboratory examinations of a group of patients. They recited briefly the history of the disease and the various theories concerning its etiology. Their own studies yielded the following results: 1. Chemical analysis of the blood and excreta showed that there was calcium retention despite a fall in the blood calcium. 2. An unusually rapid rise in the rate of absorption of sugar was noted. 3. The administration of epinephrine hydrochloride caused a decrease in the blood calcium. There was also a quick response of the blood pressure and a rapid return to normal. From this fact they concluded that in Paget's disease there is a polyglandular disturbance of internal secretion resembling parathyroid disturbance. They explained the pathologic picture as an increase in the permeability of the tissues entailing an inability of the osseous structure to retain calcium and the entire condition as due to a hypersecretion of the parathyroid gland.

#### ANATOMIC STUDIES

*Symmetry of the Bones in Fetal Life*—Koenig and Kornfeld<sup>18</sup> examined and measured the length of the bones in forty-two embryos and infants, and found that asymmetrical development of the bones, especially in respect to length, is common in fetal life, but generally disappears before or shortly after birth. The left clavicle and the left scapula are generally longer than the right clavicle and right scapula. The upper ribs on the left side also are usually longer. The relations between the length of the long bones of one extremity and of the bones of the leg to the bones of the arm change constantly during fetal life.

16 Brockman, E. P. *Brit J Surg* **14** 634 (April) 1927.

17 Van Hazet, Willard, and Andrews, Edmund. *Surg Gynec Obst* **45** 54 (July) 1927.

18 Koenig, K., and Kornfeld, W. *Ztschr f d ges Anat* **82** 657, 1927.

title) that Ménière thought this condition was due to cerebral hemorrhage or to hemorrhage into the semicircular canals. He made it clear that the symptoms are considered by all authorities to be due to cerebral congestion, but he repeatedly emphasized his belief that they are surely due to a disease of the internal ear. Elsewhere he said "The signs of cerebral congestion, so called, are not too well established, and—the signs of cerebral congestion and apoplexy will have to be revised" in his paper Ménière referred to the work of Itard (published in 1825) in his paper At times, Itard is unjustly given credit for the discovery of Ménière's syndrome, but, according to Ménière he assembled cases of epilepsy, hysteria and other conditions with those of aural vertigo and classified all of them as "cerebral apoplexy." It is interesting that at the meeting of the Academy of Medicine of Paris when Claude Bernard was almost unanimously elected to be a member, the subject of cerebral congestion was discussed at length, and Ménière's work was cited as argument in opposition. It was the sense of the meeting that since "there was so much contradiction, confusion and exaggeration on this subject it was better to separate epilepsy and confine the attention to true cerebral congestion." Ménière maintained that there could not be any possible relationship between epilepsy and aural vertigo, because epileptic persons do not have unilateral deafness, and patients with aural vertigo do not lose consciousness nor have the mental stigmas so common to persons with epilepsy.

Ménière's belief in the site of the lesion in the disease which has since borne his name was largely due to the well known experiments on extirpation of the semicircular canals by Flourens (1842). Ménière also reported gross observations made at necropsy in one case with acute symptoms, which persisted until death occurred five weeks later. The semicircular canals were found to contain "serosanguineous lymph." The brain did not show any abnormality. The observations made at necropsy by Ménière are obviously those of some acute aural condition and are not those of Ménière's disease which is now known as a chronic disease. The necropsy report of Ménière cannot be used to support his clinical syndrome, unless it be to show that such symptoms may be present in an acute form and may be referable to a lesion of the inner ear and not to the brain.

There is, in fact, no available material to indicate the character of the underlying lesion of Ménière's disease. A few cases have been reported, but all are complicated by other lesions. Politzer's patient had a tumor of the brain, Volkmann's had meningitis, Gruber's patient died of typhus and had blood tinged lymph in the semicircular canals. Evidence that Ménière's disease is due to a lesion of the inner ear is based almost entirely on the presence of deafness. In the absence of proof, it is permissible to doubt that the pathologic process is actually in

*Mechanics of the Patella*—An investigation of the mechanics of the patella was reported by Moloney<sup>19</sup> He reached the following conclusions The patella is not a lever, and the femoral condyles do not constitute an efficient inclined plane The patella owes its efficiency to the fact that it increases the distance between the axis of rotation of the tibia and the line of direction of the force that pulls on the tibial tubercle by means of the patellar ligament

*Metatarsus Atavicus*—Under the term “metatarsus atavicus” Morton<sup>20</sup> described the condition in which the first metatarsal bone is shorter than the second The symptoms simulate those of other metatarsal disorders The diagnosis depends on the roentgenologic examination

#### CHRONIC ARTHRITIS

*Sulphur Metabolism*—Cawadias<sup>21</sup> made a study of the sulphur balance in persons with arthritis deformans, employing a method originated by himself The study included observations on thiopepy (that special metabolic function of the organism through which the sulphur equilibrium is maintained), sulphur oxidation, and sulphur conjugation He found a deficient thiopepy and increase in sulphur catabolism Sulphur oxidation was not disturbed and sulphur conjugation, in some cases, was increased He concluded that colloidal sulphur treatment may be of use in certain patients with arthritis

*Gastric Function*—Miller and Smith<sup>22</sup> made an investigation of gastric function by means of the test meal in a group of 250 patients with different types of chronic arthritis They found that the incidence of achlorhydria and hypochlorhydria in chronic arthritis was five times as great in their group of patients as in normal subjects Streptococci were isolated in 92 per cent of fecal cultures Both observations, while abnormal, do not differ from those encountered in a wide variety of other diseases, and, therefore, the authors concluded that these are not primary etiologic factors, but that achlorhydria may allow more ready multiplication of bacteria in the bowel and may be an accessory factor

*Basal Metabolism*—A careful study of the basal metabolism in 200 patients with chronic arthritis was made by Swaim and Spear<sup>23</sup> The patients were divided according to the classification of Goldthwait, Painter, and Osgood They found that age, duration of disease, and activity of the disease do not have any effect on the metabolic rate In the atrophic and hypertrophic types the tendency has been toward a minus rate In some of the patients, treatment by thyroid extract was attended by an immediate further drop in the metabolic rate As the

19 Moloney, J C J Bone & Joint Surg 9 476 (July) 1927

20 Morton, D J J Bone & Joint Surg 9 531 (July) 1927

21 Cawadias, A P Lancet 1 1283 (June 18) 1927

22 Miller, S, and Smith, F B Quart J Med 20 271 (April) 1927

23 Swaim, L T, and Spear, L M Boston M & S J 197 350 (Sept 1) 1927

the semicircular canals. In fact, by analogy with other conditions, it is easier to believe that the nerve itself and not the end-organ may be primarily involved. It is evident from histories of Menière's disease that infections of the middle ear have no etiologic relationship. Menière early called attention to the absence of otitis media and of hereditary factors in the explanation of an underlying case.

#### TREATMENT IN MENIÈRE'S DISEASE

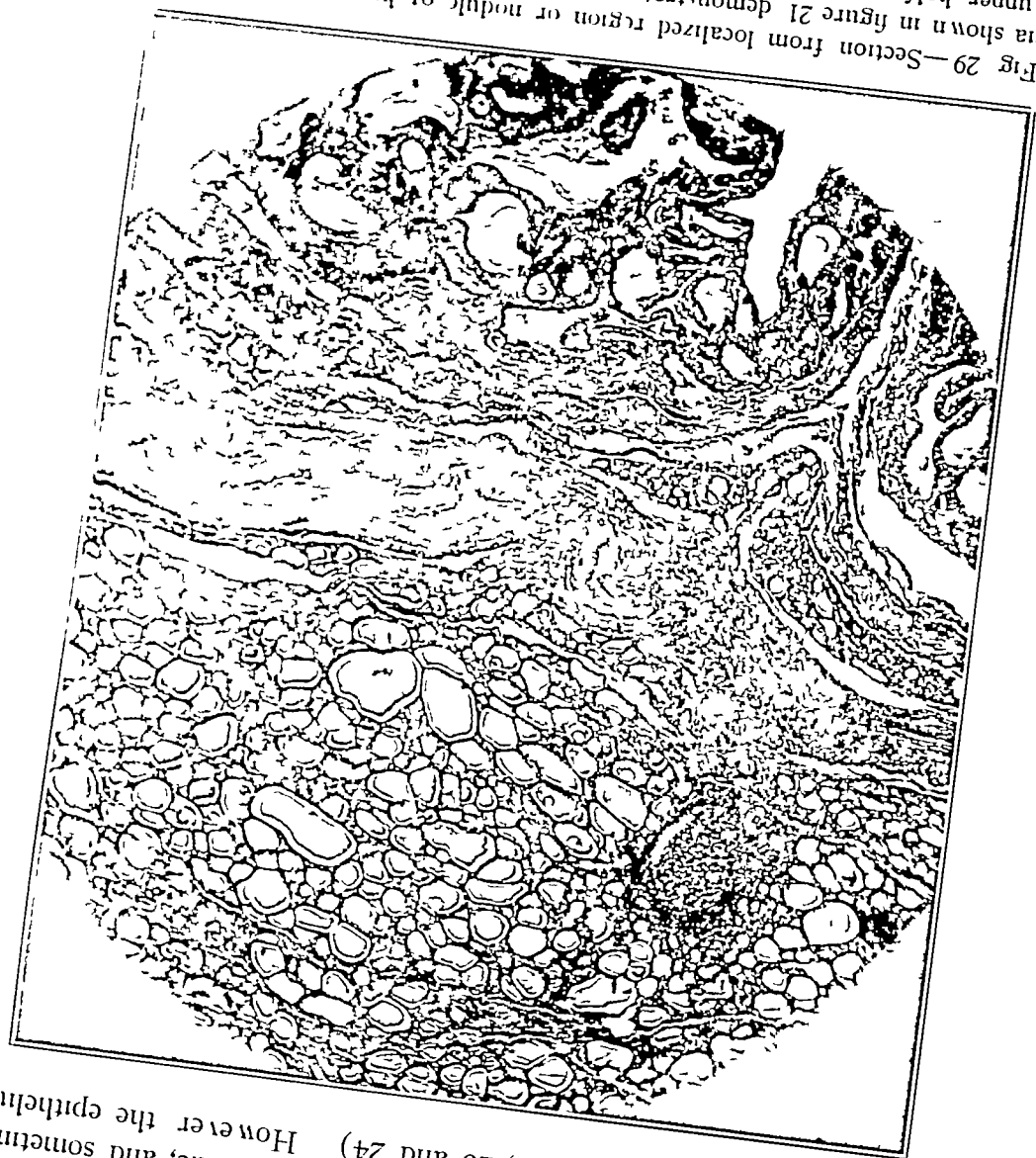
Charcot (1874), who frequently demonstrated cases of Menière's disease at his clinics, admitted the utter hopelessness of all forms of treatment then in vogue. He noted that when deafness became complete the disease stopped spontaneously. This observation prompted him to wonder if surgical intervention might not at some future time offer the solution by dividing the auditory nerve. But this suggestion was made when antiseptic surgery was just beginning and several years before the dawn of brain surgery. With one exception the attempts at surgical treatment have been directed toward the semicircular canals.

Frazier (1912), following a suggestion by Mills (1908), divided the auditory nerve intracranially in a single patient and precisely as in the operation here described, but the dizziness was not relieved. A study of Frazier's case leads one to doubt that the diagnosis of Menière's disease was correct, the characteristic "attacks" of dizziness, nausea and vomiting were not present. Rather there was a chronic state in which dizziness could be induced by postural change. The patient also was unable to lie in comfort on the contralateral side. These symptoms would seem to indicate involvement of the cerebello—brain stem—vestibular paths by a neoplasm or inflammatory process. Furthermore, there was the history of influenza quickly followed by deafness—an etiologic relationship not recognized in Menière's disease.

Section of the eighth nerve for persistent tinnitus was then tried by Frazier (1913), but the ultimate success is not known. He stated that "the intense roaring sound" had disappeared at the time of the patient's discharge from the hospital. The results in the cases reported in this paper make one wonder how far section of the eighth nerve can control noises referred to the ear.

Other surgical attempts at treatment in cases of Menière's disease have been directed toward direct attacks on the inner ear interfering through the mastoid. Stoutant trephines the labyrinth. Forstmann incises the sacus endolymphaticus. Aboulker exposes the duct behind the mastoid and expects to "decompress" the auditory nerve either with or without opening the duct. The assumption of Aboulker that an increase of pressure of the cerebrospinal fluid in the posterior cranial fossa was responsible for Menière's disease was due to H. Bantist's contention that lambert punctures relieved the same forms. At the time of the first

Fig 29—Section from localized region of nodule of hyperplasia and hyperplasia separated by an apparent capsule from the region of normal hyperplasia shown in figure 21 demonstrating the sharp localization of the process. In the upper half of the section the thyroid parenchyma is of normal hyperplasia appearance separated by an apparent capsule from the region of hyperplasia. The lower half of the section shows the typical changes of hyperplasia manifested by the epithelial elements as well as the presence of hyperplasia manifested by the typical changes of hyperplasia. Magnification of  $\times 57$ .



of histologic preservation near the periphery of the area or lobule (figs 20, 22, 23, 24 and 32). Toward the center evidences of histologic regression were encountered in the form of diminution in the number and size of the acini with a marked increase in the intra-acinar stroma forming large scars or patches of fibrous tissue, and sometimes large cystic areas (figs 20, 22, 23 and 24). However the epithelium

lobule (figs 13, 17, 18 and 24) The histologic structure of the parenchymatous portion of these nodules or areas was similar in all details to that characteristic of a lobule of hyperplastic parenchyma occurring in exophthalmic goiter (figs 12, 13, 20, 21, 22, 23, 26, 27, 28, 29, 30 and 31) The microscopic appearance of histologic regression and disinte-

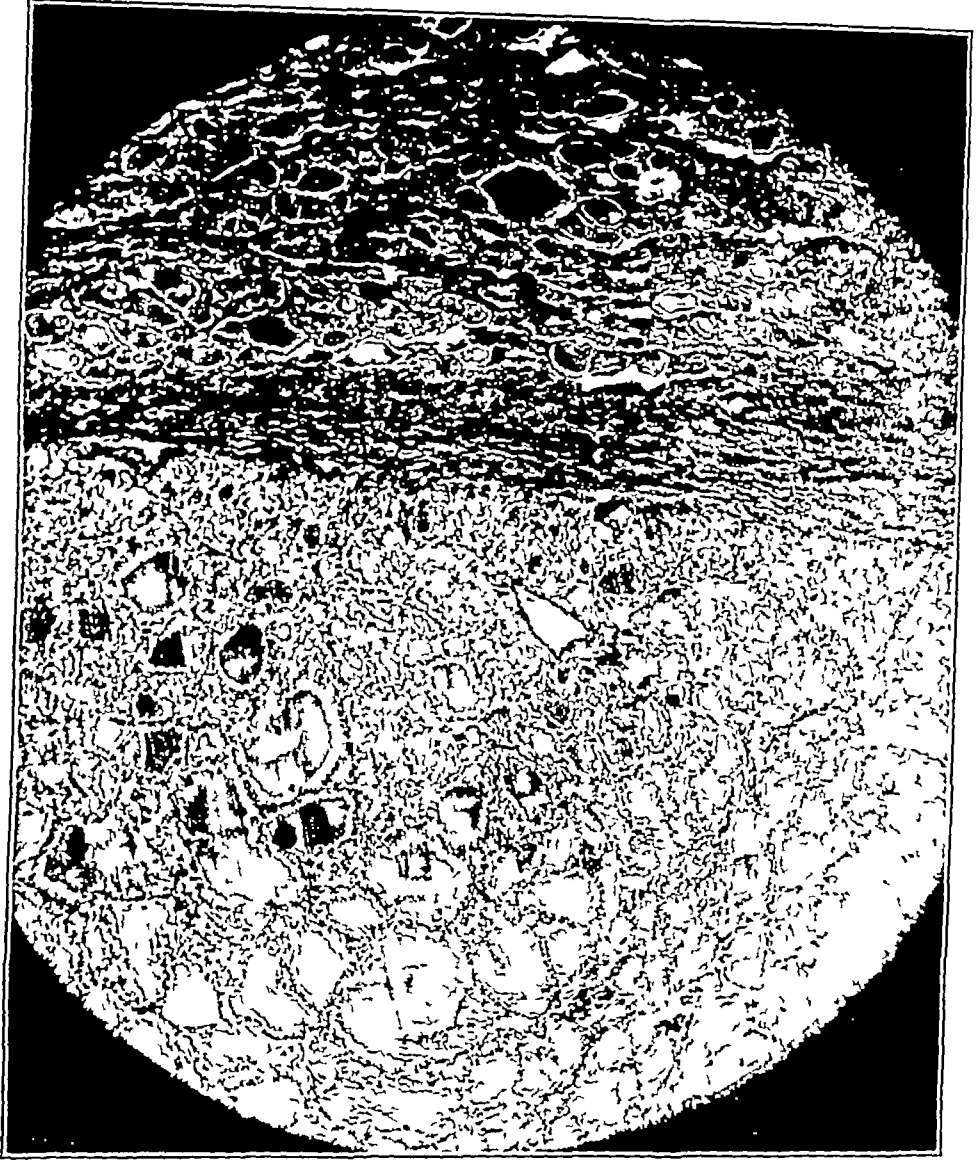


Fig 30—Section of tissue from tumor and contiguous tissue shown in figure 26 In lower half of section can be seen the typical microscopic pattern of hypertrophy and hyperplasia This tissue came from the tumor side The apparent capsule consists of compressed interlobular and intralobular septums between which atrophic acini can be observed In the upper portion of the section normal thyroid tissue can be seen Reduced from a magnification of  $\times 56$

gration with cyst formation noted toward the center of the areas was characteristic in every respect of the involutional changes observed and described as occurring throughout the gland as a whole following arti-

national Congress of Otology in 1922, this theory was supported by Nylen (Stockholm) and Quix (Utrecht). In refutation of this assumption it is only necessary to say that Meniere's disease is never seen when the intracranial pressure is really increased as in tumors of the posterior cranial fossa. An increase of pressure around one auditory nerve, aside from being pure conjecture, is impossible because the cisterna lateralis which surrounds the auditory nerve is freely open in three directions. In none of my operative series was there the slightest evidence of increased intracranial pressure, either local or general.

#### REPORT OF CASES

**CASE 1—History**—A well nourished man, aged 53, was referred by Dr. G. H. Barksdale, of Charleston, W. Va., in September, 1924, because of vertigo, nausea, vomiting and buzzing in the left ear. The symptom of the onset was a unilateral buzzing in the ear which began two and one-half years previously. Impairment in hearing was noticed at the same time and had progressed gradually. Two months before examination, a headache began in the morning, later in the day, the patient became very dizzy. He went to bed, but the vertigo continued throughout the day. There were severe nausea and persistent vomiting. Everything seemed to move to the left. He said that he believed he would have fallen to the left if he had not gone to bed. Other attacks occurred but they did not last longer than a day. Three days before admission he had the most severe attack which wakened him out of a sound sleep. He saw objects moving to the left, and was greatly nauseated for five hours. Numerous attempts to vomit were ineffectual. A friend who saw him in this attack said that the temperature was 97 F and the pulse rate, 60. For the past few months he had had a little headache over the occiput. The headaches were never severe, but were much worse during the attacks. Ringing in the left ear had been present since the onset of the condition. It was more intense during an attack. There had never been infection of the middle ear or mastoid.

**Neurologic and Physical Examination**—With the exception of a questionable positive Romberg test (with tendency to fall to the left) and the disturbance referable to the eighth nerve, the results of the neurologic examination were negative. The patient had a bradycardia (60) during an attack. The Wassermann reaction of blood was negative. According to the tests the hearing in the left ear was moderately impaired, a watch tick was not audible. C 64 was not heard in the left ear, C 128 was heard only one fourth of normal time. C 1024 and C 2048 were not greatly changed. Bone conduction was greater than air conduction.

Vestibular tests showed that spontaneous nystagmus was not present. There was a normal response to caloric stimulation of both ears, but the left ear (affected side) was more quickly induced than the right.

**Operation**—The left eighth nerve was divided intracranially under local anesthesia. The patient did not experience any sensation when the auditory nerve was dissected and divided. The postoperative course was uneventful.

Three and a half years after the operation, the patient was in perfect health and has been actively at work for the past three years. He has never had the slightest suggestion of an attack since the operation.



TABLE 1—Data Showing General

Case	Sex*	Age	Side Involved	Duration of Symptoms	Duration of Hearing Loss	Dizziness	Thinnitus	Nausea	Vomiting	Self or Objects Turning	Affected Side	On Opposite Side	In this column ♂ indicates male ♀ female									
1	♂	53	Left	2½ yr	2½ yr	+	+	+	+	Objects turn to left	During Attacks Dizziness Made Worse by Lying on Side	On Opposite Side										
2	♀	54	Left	3 yr	1 yr	+	+	+	+		More comfortable on affected side	+										
3	♀	55	Right	1½ yr	1½ yr	+	+	+	+++	Objects turn first one way then another, also if she is turning	Comfortable only when lying on back of head	Cannot lie on either side										
4	♂	47	Left	1 yr	6 mo	+	+	+	+	Thinnitus began six months after first attack	No	No										
5	♂	33	Left	2 yr	1½ yr	+	+	+	No	Objects right to left	Made dizziness worse	More comfortable on opposite side										
6	♀	54	Left	6 yr	6 yr	+	+	+	+++	Objects turn without consistent direction on affected side (left)	For years unable to lie on affected side (left)											
7	♀	33	Left	15 mo	15 mo	+	+	+	+	Sensation that she is turning to the right	Changes menses worse	No difference										
8	♀	32	Left	5 yr	2 yr	+	+	+	+	Sensation that she was rocking back and forth, objects also whirl but without definite direction	Position difference all comfortable	No difference										
9	♀	47	Left	5 yr	5 yr	—	+	Almost constantly absent	+	Objects turn from right to left	Can lie only on back of head	Can lie only on back of head between attacks										

**CASE 2—History.**—A well nourished woman, aged 54 was referred to me by Dr Julian Chisolm, on Nov. 10, 1924. For three or four years the patient had had occasional attacks of dizziness and vomiting. At first they were not severe. One year before admission, she had a severe attack associated with ringing in the left ear and some impairment of hearing in the left ear. She was confined to bed for four days and found that she was much more comfortable when lying on the left side. Two months later, an even more severe attack prostrated her. It was like the preceding one, except that there was pain in the left occipital region and occasional tingling and numbness of both hands. There were also zigzag flashes of light. For the past three months before consulting me there had been a constant tinnitus in the left ear, some unsteadiness of gait and a constant dull ache in the region of the left mastoid. There was no history of otitis media.

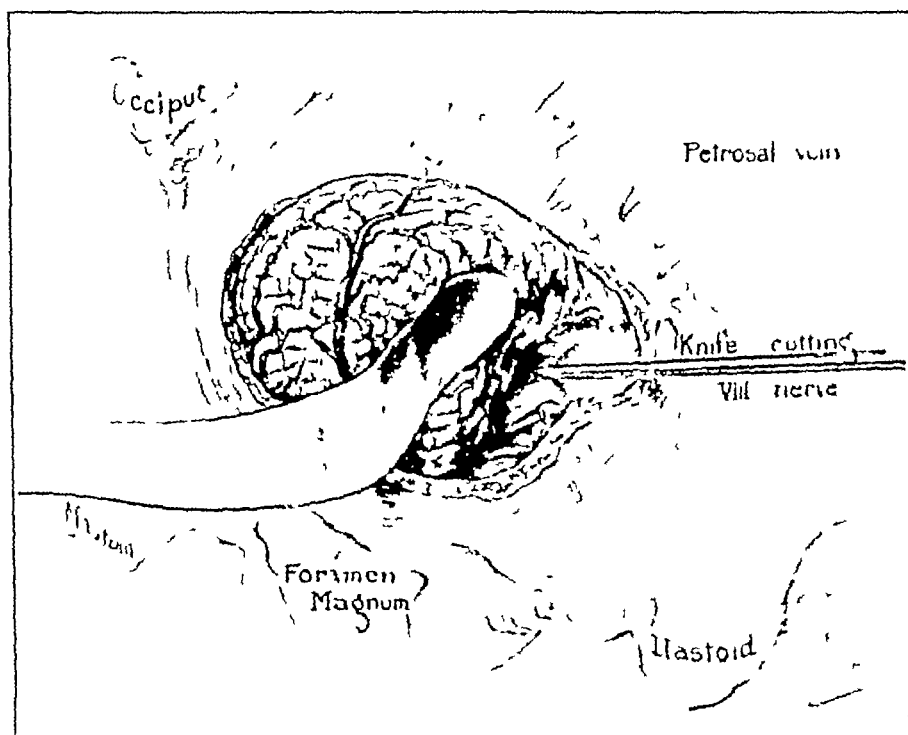


Fig. 1—Operative approach to region of the eighth nerve. The nerve can be divided either with a blade at right angles to a long shaft or with a small pair of scissors.

**Examination.**—The results of the physical examination and the Wassermann reaction of blood were negative. The results of the neurologic examination were negative, except for changes referable to the auditory nerve.

The hearing test revealed total deafness in the left ear; the right ear was normal.

The caloric test did not show any response to irrigations of the left ear; the right was normal.

**Operation.**—The left auditory nerve was sectioned intracranially on Nov. 12, 1924, under ether anesthesia. The patient was discharged from the hospital ten days later.

She has not had any attacks since operation. She complains of a dull, aching, night feeling in the occipital region at the operative field and a dull ache in



the eyes, this sensation has been present for more than twenty-five years. Sometimes there is a little dizziness with the flashes of light (migraine?)

**CASE 3—History**—An undernourished woman, aged 55, was referred by Dr Barker on Jan 11, 1927, because of Meniere's disease. She was exhausted from prolonged vomiting. Her skin was sallow and pale. Eighteen months before, she was suddenly seized with dizziness, nausea and vomiting. The attack lasted all night. The vomiting was described as projectile. She did not have any fever, chills or pain. She had never been well since the onset of the condition. Six weeks later, she had another attack precisely like the first.

The interval between attacks gradually lessened, until the patient was admitted to the hospital. Each attack lasted one or two days. Only hypodermic injections of morphine gave any relief. Six months before coming to the hospital, she had a prolonged attack during which she did not take food for five weeks. A diagnosis of gallstones had been made in her home town, and the gallbladder had been drained. Gallstones had not been present. The appendix had also been removed at the operation. Her attacks of dizziness, nausea and vomiting persisted as before, though possibly with some moderation. Five weeks before admission her most severe attack began and still persisted. Since the attack began, she had had scarcely any food. She said she felt as if she were going round, first one way, then another. The attacks were not brought on by change of position, but during an attack she could not lie on either side. Sudden movements of the head then intensified the attack. There had been a gradually progressive loss of hearing in the right ear since the onset of the present illness. At the time of consultation, she could hear but little on the right side. There was also a continual ringing in this ear which became much worse during attacks. Recently, there had been some ringing in the left ear. An occasional slight pain was experienced in the right ear. There had never been an infection of either ear or mastoid. Nothing in her past history appeared to have any bearing on her condition. An attack of rheumatism, localized to the right hip, was noted thirty-five years before. During the menopause, two or three years previously, cynosis of the fingers had been noted. She had always been nervous. Since her trouble began (eighteen months before), she lost 26 pounds (11.8 Kg).

**Examination**—The patient was in Dr Barker's medical service for one month. There were few days during this time when the dizziness, nausea and vomiting were not present. The vomiting was often projectile. During most of this time she could retain nothing by mouth and was given fluids by rectal, subcutaneous and intravenous methods.

Except for the disturbed functions of the eighth nerve, the results of the neurologic examinations were entirely negative.

Examinations of auditory and vestibular functions were made by Dr Baylor. All tuning forks were heard on the left side within normal limits. On the right, there was marked shortening with all forks. Vibrations of tuning fork C 128 were barely heard to C 2048.

Irrigation of the right ear produced a rotary nystagmus to the left, but no subjective dizziness. Irrigation of the left ear caused a rotary nystagmus to the right, but no subjective vertigo.

The audiometer test showed loss of hearing in the right ear and of some of the high tones in the left ear. The vestibular function was not abnormal.

The Wassermann reaction of the blood was negative. The blood pressure was 110 systolic and 70 diastolic.

**Operation**—On Jan 11, 1927, intracranial division of the right auditory nerve was performed under local anesthesia. The patient was not conscious of any

cases there were losses of 18, 27 and 30 per cent in the good ears. These losses may or may not have any relationship to the other ear, which is the participant in Meniere's syndrome

One of the most surprising observations is the great variability in the results of tests of vestibular function. If Meniere's disease is really a primary lesion of the semicircular canals, it is fair to expect the vestibular function to be profoundly and uniformly disturbed, at least, it should be more disturbed than the auditory function. On the contrary, the acuity of response from caloric stimuli is found undiminished in three cases, and only slightly diminished in another

Three of the patients in the foregoing case reports had headache during the attacks. In two cases, the headache was on the side of the lesion and more in the occipital region than elsewhere. In another instance, the headache was general. One patient had a "queer" feeling in the head just before an attack. She looked on this as an infallible warning sign

One patient thought there might have been on one occasion momentary loss of consciousness. In none of the remaining cases was there a suggestion of loss of consciousness. The preservation of consciousness is indeed one of the striking characteristics of Meniere's disease. A distressing desire to urinate and defecate during an attack made it necessary for one patient to lie on the bedpan until the attack was over. Two patients complained of some general dizziness or "light headedness" between the seizures. In both of these cases the dizziness persisted for several months after the eighth nerve was divided, it gradually abated and in less than a year it had almost completely disappeared. Nystagmus, which is occasionally reported in cases of Meniere's disease, was not observed in any of the cases from this series

#### PSEUDO-MENIERE'S ATTACKS

The question has often been asked whether unilateral deafness is a necessary sign of Meniere's disease. Frankl-Hochwart suggested the term "pseudo-Meniere's" to apply to cases which seem similar but lack the unilateral deafness. The following history is presented as an instance of so-called pseudo-Meniere's disease because the attacks seem similar, yet without any subjective or objective evidence of impaired hearing, and no unilateral signs

A man aged 59, referred by Dr. S. J. Crowe, for the past eight or nine years had been having recurring dizzy spells associated with nausea and vomiting. During the attack everything whirled about him. He could not lie on the left side or on the back of the head. The attacks averaged about two a year. There was some tinnitus in both ears. At the onset of his trouble, attacks appeared almost daily for over a month gradually disappearing. Other spells lasted only a few days, but they were fearful, and he lived in terror of their reappearance. The whirling

sensation either when the auditory nerve was being liberated or when it was being divided. The postoperative course was uneventful.

Fourteen months after the operation, there had not been the slightest evidence of an attack. She had regained her original weight and more and was well.

**CASE 4—History**—A large robust man, aged 47, was referred in April, 1927 by Dr. F. C. Schreiber of Washington. One year before, the patient had felt dizzy when he awoke and raised his head. He vomited, but was not nauseated. He was bedfast for three days. He felt dizzy every time he moved his head and vomited nearly as often. It was three weeks before the dizziness entirely disappeared. Four months later, he had another attack exactly like the first but this lasted only a week. Seven months before, tinnitus and deafness developed in the left ear, both appeared suddenly during an attack of dizziness and vomiting. The attacks of dizziness were not associated with moving objects. Headaches were not present. The patient reeled and staggered when walking during an

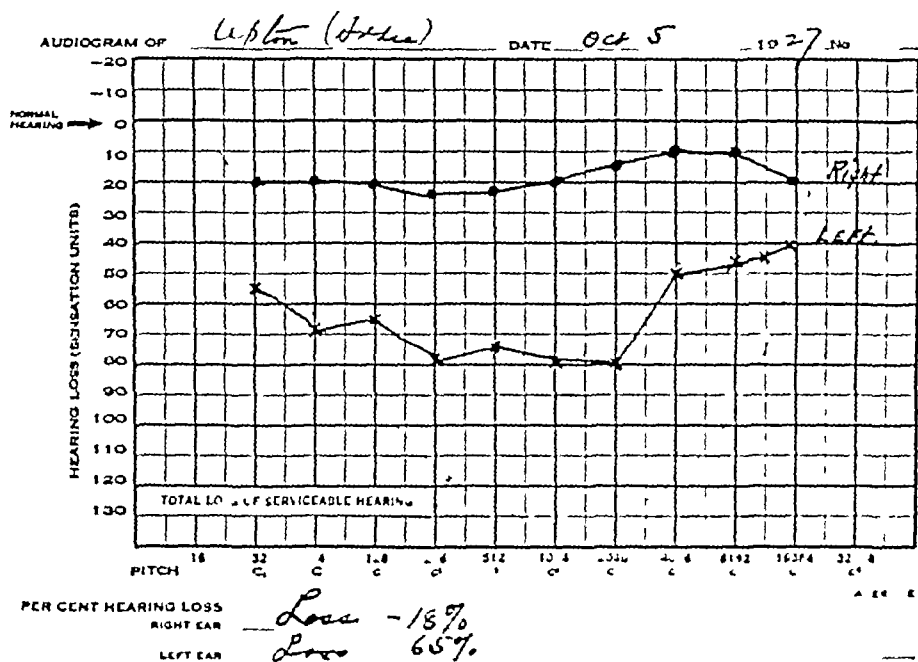


Fig 2—Audiometer chart showing the loss of hearing in a typical case of Meniere's disease

attack. During the past month, there had been no additional attacks but the patient was always dizzy. He complained of poor memory during the recent attacks.

**Physical and Neurologic Examinations**—A positive Babinski sign and ankle clonus were present on the left side. The only other positive symptoms were the disturbed function of the eighth nerve. Unfortunately, the audiometer and caloric records of the functions of the vestibular and auditory divisions of this nerve were lost. It was recorded however that air conduction was less than bone conduction in the left ear and that hearing was best for the high notes and diminished for the low tones.

The blood pressure was 125 systolic and 85 diastolic. The Wassermann reaction of blood was negative.

The unilateral Babinski sign and ankle clonus made the diagnosis of Meniere's disease rather uncertain.

objects continued with his eyes shut but not so severely. Between attacks he was well in every way. Hearing was not impaired and there were no headaches. The results of the physical and neurologic examinations were negative in every respect. Hearing tests were normal in both ears. Caloric tests gave normal response in both ears.

Although pseudo-Alzheimer's attacks are usually considered to be of hysterical origin, Politzer suggested that in some cases the organic evidence of disturbed hearing may be late in appearing. The analysis of my cases might seem to give support to this view for in three cases the loss of hearing (subjective) was not observed until long after the onset of the dizzy attacks. In the foregoing case however the attacks have been present for eight or nine years—far longer than the hearing-free interval in any of my cases. The patient did not have any unilateral manifestations during the attack except that he could not lie on the left side or back of the head. Such a history would seem to preclude a hysterical attack. It is hardly possible that dizziness of this type could be simulated. Moreover, the patient is a practical, placid and unemotional person. The following report is from the most severe case of dizziness in my experience and differed from all others.

*Idioma (Fuephabhis [?]) of Cerebellum Producing Vertigo and Tremulousness*—A well-nourished woman aged 43, was referred by Dr. Harry Slack of Little Rock, Arkansas, for treatment. For three weeks, she had been bedridden with dizziness which is almost constantly present. It was least when she was on her back, became greatly intensified with every movement of the head to either side. Any attempt to raise the head off the pillow instantly brought on such intense dizziness that the patient feared she would pass into coma. She was almost always nauseated and vomited many times. This illness came on suddenly and without an antecedent illness or infection. She complained of a feeling of pressure in the suboccipital region.

*Examination*—The results of the physical and neurologic examinations were normal. There was no titubation or nystagmus. There was no disturbance of hearing in either ear. Caloric tests gave a normal response on both sides. Cervical rigidity was not noted. The temperature was never elevated. The pulse count was 134 (100 and 158). Lumbar puncture was performed for fluid. The pressure was subnormal, the fluid dropping only slowly. The rate of the sedimentation test was normal. Examination of the fundi showed no abnormality. There were 3 cells and no globulin. The Wassermann reaction of the spinal fluid was negative. The cerebrospinal fluid had been clear and normal until the first few days when the cells became 100 per cubic millimeter. The margins were und mixed.

*Course*—All forms of medical therapy proved without effect. The patient was rapidly growing worse and presented a picture of a severe case of the disease. On March 17, 1927, a general anesthetic was given. The patient was unconscious for 12 hours. The cerebrospinal fluid was normal. The patient was well in every way. The results of the physical and neurologic examinations were negative in every respect. Hearing tests were normal in both ears. Caloric tests gave normal response in both ears.

*Operation*—In March, 1927, the left acoustic nerve was divided intracranially under local anesthesia. Thorough exploration of the cerebellopontile angle did not disclose a tumor. The entire intracranial course of the eighth nerve was in full view. Later, the symptoms did not clear up, and it was found by caloric tests that vestibular function was still present, though there was total deafness. Apparently, in an effort to avoid the facial nerve, the vestibular division of the nerve had not been divided. Two weeks later, the wound was reopened and this branch sectioned. The facial nerve was also injured despite caution. This was the only injury to the facial nerve in the series. It was later corrected by a spinofacial anastomosis.

The patient had not had attacks of dizziness and vomiting one year after the operation, but it is only fair to recall that for seven months prior to the operation he had had no attacks. After the operation he still complained of the constant dizziness which he described as lightheadedness and which was also present before operation. This steadily diminished after operation, until it was barely noticeable. The patient insisted that this dizziness was always worse in damp weather. It did not seem probable that it was caused by the disturbance of the eighth nerve, for it was unaffected by its section and seemed entirely independent of the attacks.

*CASE 5—History*—A well nourished man, aged 33, was referred to the hospital in June, 1927, because of dizziness. Two years before, he had suddenly become dizzy while at work. He continued at work but after an hour it was necessary to stop. A month later, a similar attack of dizziness had occurred while he was at work, and it had lasted all day. Nausea or vomiting were not associated with the attack. Objects always rotated from right to left, i. e., toward the deaf ear. During an attack he could not lie on the affected side, the dizziness was less when he was lying on the opposite side. At first the attacks recurred about every month, but there had been one free interval of seven months. During the past year there had rarely been an interval of longer than a week between attacks. In an effort to obtain relief, the nasal sinuses had been operated on, and the gallbladder had been drained. There were some left-sided headaches from the beginning, but they were always more intense just before an attack. A year and a half before admission, loss of hearing was noticed in the left ear, it had steadily progressed. Buzzing and ringing in the left ear had been present constantly for about the same length of time.

*Examination*—The results of the physical and neurologic examinations were negative, except for tests of hearing and vestibular function. The audiometer test showed a 58 per cent loss of hearing in the affected (left) ear and 27 per cent in the right ear. In the vestibular tests, caloric irrigations to the left ear did not give any response, they were normal to the right ear.

*Operation*—On June, 1927, under ether anesthesia, the left auditory nerve was sectioned at the internal auditory meatus. The patient had an uneventful recovery.

Ten months after the operation, there were no signs of recurrence of the attacks. There was occasional tinnitus.

*CASE 6—History*—A highly nervous, well nourished woman, aged 54, was referred by Dr. P. S. Sisco of Baltimore. For six years she was subject to violent dizzy spells which came on without warning and were accompanied by nausea and vomiting. The duration of the attacks varied from a few minutes to eight hours. During the attack she was afraid to move, for any change of position exaggerated her symptoms. Her first attack had occurred when she awoke from a sound sleep. Objects moved from left to right, i. e., away from the lesion. The



cranial fossa—was obliterated. The tonsils of the cerebellum had herniated into the spinal canal completely filling the foramen magnum. To liberate them, the dura was split in the midline to the atlas. The lateral ventricle was tapped in an effort to decrease the pressure, but there was no hydrocephalus. The cerebellar lobes were equal in size and looked alike, both appeared much smaller than normal. There was no apparent cause of the great pressure. There was no surface appearance of a tumor, and the short duration of such fulminating symptoms seemed to make the presence of a tumor unlikely. An extended search was not made for a tumor. There was no evidence of an inflammatory process. It was difficult to close the muscles owing to the pressure. A bilateral cerebellar decompression remained and constituted the only therapy resulting from the operation. The dizziness at once disappeared and had not returned one year after operation. It is also noteworthy that after the operation the patient could lie in any position without inducing dizziness.

*Comment*—The swelling of the cerebellum was undoubtedly due to edema, but the cause of the edema remains obscure. A few months after the operation the decompression was soft and did not protrude. The swelling of the brain, therefore, must have subsided. If a tumor had been present, the decompression would have become progressively tighter. Perhaps in the absence of any recognizable cause the lesion may be considered a form of encephalitis. The cerebellar edema does not suggest in any way angioneurotic edema described by Oppenheim as a not uncommon cause of Mènière's disease. The absence of increased pressure by spinal puncture was due to the fact that the cerebellar tonsils had filled the foramen magnum and prevented the transmission of cranial pressure. The symptoms in this case differ from Mènière's disease in the constancy of the symptoms and the absence of attacks with associated deafness. They differ from pseudo-Mènière's also in the absence of attacks. The symptoms are associated with organic cerebellar lesions, which will be considered shortly.

#### MÉNIÈRE'S ATTACKS DUE TO A LOCALIZED LESION ON THE AUDITORY NERVE

That attacks with the characteristic symptoms and signs of Mènière's disease may be due to a localized lesion involving the auditory nerve is shown by the following case report.

*History*—A rather feeble woman, aged 66, was seen in consultation with Dr. Leslie Gay of Baltimore. Her first symptoms were gradually progressive deafness and tinnitus of the left ear (the right ear was almost deaf from an old infection during childhood). One year later she was suddenly and without warning seized with a terrific attack of dizziness during which there was nausea and repeated vomiting. The room seemed to jump around, the bed to tilt up and the walls to move in every direction. There was no definite revolving sensation. The attack lasted about thirty minutes. Brief spells of much the same character have since occurred almost daily. Any quick movement will induce dizziness. The deafness varied greatly from time to time. Tinnitus was constant in the left ear. Her eyesight became so poor that she could not read. She never had headache.

attacks averaged two or three a month. Vomiting was persistent and exhausting. There was also a distressing desire to micturate and defecate and since she lay motionless to reduce the dizziness as much as possible she had to remain on the bedpan throughout the attack. After a seizure she fell asleep, and on awakening felt well again. The attacks had greatly increased in frequency until she had several each day. A gradual loss of hearing in the left ear had occurred until she thought she was totally deaf on that side. The other ear had not been affected.

She said that for about a year she staggered like a drunken person but without a definite tendency to fall to either side. During the past month she had felt



Fig. 3—Scar after operation at which the eighth nerve was resected intracranially for Meniere's disease.

dizzy almost constantly. Recently any sudden motion of the head precipitated an attack. For years she had been unable to lie on the affected (left) side. Tinnitus—a ringing noise—had been present in the left ear since the onset of the condition six years before. She thought her memory was affected. Occasionally before an attack she noticed that everything seemed bright but faded in a definite visual aura. She also had a vague impression of smelling something before an attack but she could not give any better description of the odor. There was no history of otitis media.

*Pathologic*—The results of the physical examination were negative. Wassermann reaction of the blood was negative.

Her systolic blood pressure varied greatly during Dr Gray's observations over a period of several months. Usually it ran from 160 to 190, but has been as low as 110. Her hands and feet were swollen at times, even when in bed, at other times, the swelling was absent.

One month before operation her symptoms became much more severe. Roaring ears. The hearing became much worse. Her gait was unsteady and uncertain. The left corneal reflex was diminished.

Caloric response on affected side was normal. Irrigations started mild attacks of dizziness and nausea.

The audiometer test showed 63.5 per cent loss of hearing in the right ear (aided), and 65 per cent loss in the left (affected side).

*Operation*—On Nov. 22, 1927, a section of the left auditory nerve was performed. An aneurysm was found under the eighth nerve. It was traced downward and was continuous with the vertebral artery. Two days after operation, the old noises returned. One week later, it was noted that she could not lie on the left side (nerve cut on this side) for any length of time because nausea and vomiting would start, but dizziness had not been present since operation. The patient's condition became slowly worse and the noises became unbearable. She was unable to stand. Three weeks later, the left vertebral artery was tied in the neck. At the same operation, the right vertebral artery was exposed and pinned between the blades of the forceps, death resulted apparently simultaneously and instantly. Immediate release of the forceps was unavailing.

This case is presented as an illustration of a tumor (aneurysm) pressing on the eighth nerve and giving symptoms which, until later neurologic symptoms appeared, did not seem different from those of true Almer's disease. It will be noted also that the bilateral aneurysm was so situated that the vestibular function was not affected, it being as indicated by caloric tests. The case also illustrates the fact that a primary lesion of the semicircular canals or of the cochlea is not necessary for the induction of attacks of the Almer's type and that a lesion of the nerve itself and more specifically of the cochlear branch alone can cause them. I am reminded of the analogy with trigeminal or glossopharyngeal neuralgia, in either of which in their usual form a sustaining cause is not demonstrable, but occasionally a cerebrobony point may be identified with the same paroxysmal tickle pains.

In this case moreover the dizzy spells which were present daily before the operation appeared to stop just as definitely and completely after section of the eighth nerve as in the cases of Almer's disease. It is also worthy of note that noises referred to the ear and vertigo which they became distressing and almost unbearable. Nocturnal attacks must at times at least have an explanation other than a mere reflex mission.

Another point is brought out in the analysis of the case, namely, that while at first the onset of the attacks was intermittent, as was the case with the other to posteriorly located lesions, the attacks were followed by a period of complete recovery.

The results of the neurologic examination were negative, with the exception of the changes referable to the eighth nerve

The hearing test showed a 70 per cent loss of hearing in the left ear and 30 per cent in the right

The left ear did not show any response to the caloric test, the right ear was normal

*Operation*—On Aug 16, 1927, the left eighth nerve was divided under ether anesthesia

The patient left the hospital ten days later Eight months after the operation, she was well and had had no sign of her old attacks Only an occasional trace of tinnitus remained

*CASE 7—History*—A woman, aged 35, was referred by Dr T P Sprunt of Baltimore in April, 1927, because of attacks of dizziness Ten years before a thyroidectomy had been performed by Professor Halsted because of marked symptoms of exophthalmic goiter She had never been in robust health since the operation, but she had continued to work steadily and had not had any serious illness

She dated the onset of her condition to a sudden attack of dizziness fifteen months before when she was about to leave home She had a violent sensation of turning to the right Shortly afterward she was nauseated and vomited The attack wore off during the day Since then, similar attacks had occurred rather frequently, until she had them about every two or three weeks The dizziness never caused her to reel or fall, but there was the sensation that she was rotating to the right, i e, away from the lesion The symptoms were accentuated when she lay on the left side As long as she kept still and kept her eyes closed, she was much better Between the attacks she was free from any disturbance Since the beginning of her dizziness, the hearing in the left ear had been impaired This had been progressive Tinnitus was present almost constantly throughout her illness, but was worse, perhaps, at the time of the attacks Her past history did not shed any light on the cause of her illness She had never had otitis media or mastoiditis The blood pressure was 128 systolic and 82 diastolic The Wassermann reaction of the blood was negative.

*Examination*—The results of the physical and neurologic examinations were negative, with the exception of the local alteration in the function of the acoustic nerve

The audiometer test showed a 56 per cent loss of hearing in the left ear, the right was normal The caloric tests showed a normal response in both ears

*Operation*—The left auditory nerve was divided intracranially under local anesthesia When the acoustic nerve was being manipulated and divided, the patient complained of the same sensation of rotation and of nausea as during an attack It promptly disappeared when the nerve was severed The postoperative recovery was uneventful

One year after the operation, the patient had not had any sign of her former attacks For several months, she had had a feeling of dizziness and uncertainty when walking and was hesitant about crossing the street This has now disappeared almost entirely The noises in the ear persist as before They have become less noticeable as she pays less attention to them It is my impression that the tinnitus is neurogenic

*CASE 8—History*—A well nourished woman, aged 32, was referred from the medical dispensary Five years before she was suddenly seized with a severe attack of dizziness accompanied by severe nausea and vomiting She felt as

TABLE 2—Analysis Showing Different Kinds of Diagnosis in Menière's Disease

Patient	Location of Tumor	Kind of Tumor	Patient Can Lie in Comfort on		Dizziness Made Worse by Lying on the		Does Movement of Head Precipitate Dizziness		Do Objects Turn	Does Patient seem to Turn Gradual or Sudden	Are Attacks Accompanied by				Hearing	Remarks
			Side Lesion	Opposite Site	Side Lesion	Opposite Site	Back	Yes			Tinnitus	Nausea	Vomiting	Caloric Test		
1	Aneurysm of basilar artery	Aneurysm	No	+	+	Im proved	No	Yes			Later became roaring and on other side (to lesser extent)	+	+	Normal	68% loss, but varies from day to day	Outing stopped dizzy spells but did not stop tinnitus and old noises in ear, diminution of left ear, neural reflex, blood pressure varies from 110 to 190 gait finally became unsteady, though unaffected at first
2	Left lobe of cerebellum to the left of the center	Sarcoma	No	+	+	Im proved	No	Yes						0	Normal	Tended to fall to right in attacks (i.e., to opposite side)
3	Right lobe and vermis	Gloma	No	+	+	Im proved	No	Yes						0	Normal	Tended to fall and stagger to the right
4	Right cerebellopontine angle and lobe	Gloma	+	+	+	Im proved	Yes							0	Normal	Dizziness was described as a swimming sensation, raising head not move, brought on pillow total deafness of right ear
5	Right extra cerebellar	Sarcoma	+	+	+	Im proved	Yes							0	Normal	Tended to fall to the right
6	Left cerebellar lobe	Small tubercle 1.5 by 1.5 cm	No	+	+	Im proved	Yes							0	Normal	Dizziness was described as a swimming sensation, raising head not move, brought on pillow total deafness of right ear
7	Right cerebellopontine angle	Gumma	No	+	+	Im proved	Yes							0	Normal	Tended to fall to the right
8	Right temporal and occipital lobes	Cyst with intracystic angioma	+	+	+	Im proved	Yes							0	Normal	Unable to turn off left side for five weeks, staged necropsy showed no other tubercles in brain

though she were 'falling forward or backward,' and it was necessary for her to hold on to something to keep from falling. The next attack occurred three weeks later. Since then, the attacks had recurred with increasing severity and greater frequency, until they averaged about two or three a week. The attacks occurred without apparent cause and were not induced by movements of the head or body, they often occurred when the patient was sitting or recumbent. Objects moved before her but with indefinite direction, they seemed to whirl in a general confusion. Three years later, she first noticed that the hearing in the left ear was impaired, this progressed until she was practically deaf in that ear. There was no tinnitus. Recently, there were some dull frontal headaches, but they were not important. She said that occasionally, during the most severe attacks, she thought that she lost consciousness, momentarily, and that she had a tendency to stagger to the right during the dizzy attacks, during the free intervals, the gait was normal. Later a new feature was added to the attacks, in that there was a 'queer feeling' in the head just before the attack began. She took this as a warning signal to lie down promptly. There was no history of otitis media or mastoiditis and no known cause for her distress.

*Examination*—The results of the physical and neurologic examination were negative except for the local condition.

The hearing tests showed a marked reduction of hearing for all tones in the left ear. Air conduction was greater than bone conduction. Hearing on the right side was essentially normal, there was about 65 per cent loss of hearing on the left by the audiometer test and 18 per cent on the right.

In the caloric tests, irrigation of the left (affected) ear with ice water caused rotary nystagmus. The response of the right ear was more active.

Dr. Crowe had observed this patient for more than a year, and had made several audiometer examinations. The tests showed a steady increase in deafness.

*Operation*—The left auditory nerve was divided intracranially under ether anesthesia. The postoperative course was uneventful. Four months after the operation, there had been no suggestion of an attack. It is worthy of note that one year before the operation, the eighth nerve was explored and an anomalous artery lying on the nerve was "clipped." A unilateral decompression resulted. No improvement followed.

*Case 9—History*—A greatly undernourished woman, aged 47, was referred by Dr. J. Heyward Gibbs of Columbia, S. C., on Jan. 2, 1928. Five years before, she was suddenly seized with an attack of dizziness while walking. She did not fall, but probably would have done so if she had not sat down. She was nauseated and vomited. Since then similar attacks, lasting from three to five hours, had occurred every few weeks but not infrequently they had occurred every two or three days. After many spells she remained very weak for several days; at times it would require two weeks to recuperate. During the attack everything seemed to be turning around from right to left, i. e., toward the affected side. She could lie comfortably only on the back or her head. There was one free interval of six months and for the past nine months nausea and vomiting had been absent during the attacks. She fell during three attacks. She said that the attacks occurred so suddenly that she fell before she realized she was dizzy. The seizures varied considerably in severity. Diminution of hearing was first noticed in the left ear at the time of the first attack. The hearing gradually diminished, until she was practically deaf in that ear, but the hearing was unchanged on the other side. Tinnitus had been present at intervals in the left ear since the first attack of dizziness but was never present in the right ear. She described the sensation as a light, cold, or other impressions on the

head In other words, the real difference, if any, between the dizziness in the attacks of Ménière's and that of tumors in the cerebellum and brain stem, need not be great, for one type of dizziness can seemingly merge into the other and either may be induced by the same lesion

#### OTHER TYPES OF DIZZINESS FROM KNOWN LESIONS

In order to compare the dizziness during an attack of Ménière's disease with that associated with other known lesions of the brain, and to determine if possible the significance of differing kinds of dizziness, the analysis in table 2 has been made

It will be seen that seven of these lesions are located in the posterior cranial fossa, only one was found in the right temporal and occipital lobes It was formerly my impression that if severe dizziness, nausea and vomiting are induced or greatly accentuated when the position of the head is changed, or if the patient is practically unable to lie with the head in certain positions, the lesion, whatever its character, is probably located in the posterior cranial fossa The fact that this is not absolutely true is shown by case 8 in which the lesion is exclusively cerebral, but there is no doubt that tumors and other lesions in this general region produce dizziness as a symptom much more profoundly and in much more distressing form than tumors located in the cerebral hemisphere

I had hoped that such a striking symptom as the inability to lie on one side without starting dizziness or without making it worse and the relative or complete immunity from dizziness by lying on the other side might prove to be a valuable localizing sign, or at least indicate the side of the lesion But this does not appear to be true From the patients in whom this character of the dizziness has been analyzed and checked with the strictly unilateral lesions, it will be seen that three could lie with comfort on the side of the lesion but could not lie on the contralateral side, and five (one cerebral) could lie in comfort on the contralateral but not on the ipsilateral side One must, therefore, conclude that this symptom has no importance in deciding the side of the lesion I believe, however, that this type of dizziness is a most important indication that an organic lesion—a tumor or inflammatory process—does exist in or on the cerebellum or brain stem and possibly certain parts of the cerebral hemispheres Dizziness does not seem to be different whether tumors are within or without the brain stem and cerebellum When dizziness is present, there does not appear to be any special feature to differentiate that in Ménière's disease from the dizziness associated with tumors of the cerebellum and brain stem, or perhaps of the cerebral hemisphere In any of these conditions objects or even the person may move, and in either case change in position of the head may increase the dizziness On the whole the dizziness, nausea and vomiting are much more fulminating and profound in Ménière's disease Moreover, Ménière's is character-

whistle It was always worse after a dizzy attack. She did not think that the hearing was worse after the spells Headaches did not occur She had not had otitis media

*Examination*—The results of the physical examination were negative The Wassermann reaction of the blood was negative

The neurologic examination showed the following positive symptoms The left corneal reflex was greatly diminished, the Romberg sign was positive, the patient falling to the left Left facial weakness (but doubtful) was suggested by the fact that blinking seemed a little tardy There was no ataxia or adiadochokinesis The eyegrounds were normal

The audiometer test showed 90 per cent deafness in the left ear Bone conduction was absent for tuning forks 128 to 512 Hearing in the right ear was normal Weber's test referred to the right ear

The caloric test did not show any subjective or objective response whatever on the left, the right ear was normal

The absence of response to caloric stimulation, the positive Romberg sign and the diminished corneal reflex made me entertain the diagnosis of a cerebellopontile tumor, though the character of the attacks seemed more like Meniere's disease

*Operation*—Cerebellar exploration was performed on Jan 4, 1928 There was no tumor in the cerebellopontile angle The auditory nerve was clearly visible from the pons to the internal auditory meatus There was no sign of pressure in the posterior cranial fossa The auditory nerve was divided

The patient made an uneventful recovery and was discharged two weeks after the operation There have been no attacks to date (three months after operation) The patient wrote that she was in better health than for many years Occasional tinnitus occurred

#### SYMPTOMS AND DIAGNOSIS OF MENIERE'S DISEASE

There has not been the semblance of an attack since operation in any of the nine cases There was reason to question the cure by the operation in only one case (2) This patient is the only one of the nine who had total loss of both vestibular and auditory function (at least to our tests) at the time of the operation It is, therefore, open to question why she had attacks if the nerve was totally out of commission We are thrown on two possible explanations (1) that some slight nerve function might still have been present and have evaded the tests, or (2) that since the last attack before operation the deafness had become complete, and if this were true, the cure should and might well have been spontaneous and not dependent on surgical division of the nerve

It may be asked how it can be certain the nine cases are Ménière's disease The diagnosis was made on the objective symptoms of unilateral subtotal deafness, and in each instance, inspection of the entire intracranial course of the auditory nerve excluded a tumor or other localized space-occupying lesion Perhaps the most important single diagnostic feature of Meniere's disease is the sudden, fulminating onset of 'attacks' without warning and without recognizable inciting cause, and after the attack has subsided, the patient is again in perfect health with



the hearing never returns. An artificial cleavage between the two branches of the nerve, if attempted, must, therefore, be made with the least possible trauma.

#### IS MENIERE'S DISEASE "AURAL" VERTIGO?

Grouping of symptoms into a syndrome without an underlying pathologic basis always carries much uncertainty and a burden of proof. On the one hand, it is possible that the same symptoms may be attributable to different causes and on the other hand, different symptoms may have the same underlying cause. It is difficult to know on the basis of what particular symptoms cases may be included or excluded from Meniere's disease.

Apparently no case of Meniere's disease in its chronic form has been subjected to careful pathologic studies after death. This being true it is permissible to doubt that Ménière's disease is really "aural vertigo." There are certain data which at least make it probable that a lesion of the semicircular canals is not the cause. It cannot be reasoned that the lesion is primary in the semicircular canals because movements of the head stimulate dizziness. The examples, *par excellence*, that dizziness need not be from this source are given in the cases of dizziness due to verified tumors of the brain and allied lesions in the cases already reported. In these cases changes in posture induce dizziness and here the semicircular canals are known not to be involved. Probably stimulation of the semicircular canals induces the dizziness, but the source of the stimulus is elsewhere. It is known to be at a distance and in the nervous pathways, *i. e.*, the cerebellum, brain stem and auditory nerves. These pathways together with the internal ear form a system which when working properly controls equilibrium, and when disturbed induces dizziness. That the semicircular canals do not harbor the primary lesion of Ménière's disease is also strongly indicated by the fact that in one third of the cases reported in my series there was no appreciable alteration of vestibular function as tested by the caloric reaction. I have not felt justified in using other tests of presumed vestibular function, such as the rotation experiments, because of the patient's great dread of inducing attacks.

On the other hand, it may be reasoned that the cases of so-called pseudo-Ménière's disease are precisely like those of true Ménière's except that unilateral deafness is absent, and that in these cases the primary lesion is probably in the semicircular canals and not in the cochlea. Against this argument is the absence of any change in the caloric reactions in the foregoing case. Cases in which there is loss of vestibular function with cochlear function unimpaired have not yet been demonstrated. However in the absence of positive objective evidence, the location of the offending lesion cannot be assumed.

only a residual unilateral loss of hearing and persisting tinnitus. It will be seen from table 1 that while there are differences in detail, the general character of the attacks is much the same. Dizziness and unilateral tinnitus are the only two absolutely constant symptoms in the cases of this small series. In one patient nausea and vomiting were absent in all attacks, and in another, the nausea and vomiting, though present in early attacks, later disappeared. The character of the dizziness varies. Usually but not invariably objects rotate or whirl. Objects may seem to turn in one direction as in case 1, to the left, they may turn first one way then another (case 3), or in no definite direction (cases 7 and 9). In one case (7), the patient seemed to be turning to the right, and in another case (3), she seemed to revolve first one way then another. It is interesting to note that in three cases objects seemed to rotate toward the affected side and in two toward the opposite side.

During an attack, movements of the head intensified the dizziness in all cases. In one case increase of symptoms resulted from the movement of the eyes so that the patient had to keep her eyes shut during the seizure. Nearly all patients are at once forced to seek the recumbent position. One patient dared not move from the flat of her back or turn her head until the attack had worn off. Two other patients could not lie on either side and obtained relative freedom only when lying on the back of the head. One patient was not conscious of any difference in symptoms owing to position. Without exception movements of the head or body failed to induce dizziness after the attack had passed though one patient always slept on the opposite side because she feared an oncoming attack.

Tinnitus was uniformly present and always in the affected ear. In one case (8), however, it did not appear until five years after the onset of the attacks and even then was a minor symptom. Usually it persists in the free interval between the attacks. At times intensification of the tinnitus seems to usher in an attack and is worse during and for sometime after the seizure has passed. Tinnitus is described as ringing or buzzing sensation. In one case, tinnitus did not develop until six months after the first attack and was synchronous with deafness.

Hearing was diminished in one ear in every case usually to the point of rendering the ear almost useless for practical purposes. In recent cases in which audiometer tests were made the loss of hearing was 75 to 90 per cent. It is noteworthy that although the loss of hearing was noticed synchronously with the first attack this is not always true. In case 2 deafness was not noticed until two years after the first attack; in case 4 five months; and in case 8 three years after the first attack. It is of course possible that the earliest signs of deafness were not observed by the patient. But when the first attack occurred deafness was present in only one ear. In the remaining cases the loss of hearing was 50 to 85 per cent. In case 1 the

ized by "attacks" and in the free interval the patient is almost symptom free, whereas from tumors a more or less chronic state of dizziness exists, or at least the patient remains in a potential dizzy state. In true Ménière's disease there is an associated loss of function of the auditory nerve, and this does not obtain in tumors unless this nerve is directly compressed as was true in two of the foregoing cases or in occasional cases of cerebellopontile tumors.

It is in the cases of direct involvement of the auditory nerve by tumors that the differential diagnosis from Ménière's disease becomes more difficult. In the later stages of a tumor's growth there are other signs of pressure and of contiguous nerve involvement making the diagnosis easy, but in the earlier stages these manifestations are absent. In neither of the two cases just mentioned were there signs of pressure or of implication of other cranial nerves. On the other hand, in one of the reported cases of Ménière's there was a positive Romberg sign and a diminished corneal reflex, both presumptive signs of a tumor, but a tumor was not present. In another case there was a positive Babinski sign and ankle clonus on the side of the deafness, but seemingly neither was significant. One of the important features of the operation here described is that a tumor if present will be disclosed and if not present the only alternate diagnosis would seem to be Ménière's disease, and for this section of the eighth nerve is the rational treatment.

At times one is confronted by Ménière's disease affecting the only good ear. A case in point was seen by me several months ago and was recently explored. There was some variation from the usual story of Ménière's disease in that the hearing varied greatly from time to time, often suddenly and without apparent explanation. On the chance that a gross lesion might account for this phase of the symptoms—the basilar aneurysm heretofore referred to gave a similar story and was in fact the only case of either series with such variation in hearing—the nerve was explored but there was no tumor. Since it did not seem justifiable to sacrifice his hearing, the auditory nerve was not divided.

In one of the patients from this series, the vestibular and cochlear branches of the auditory nerve were separate and distinct, such an anatomic variation would lend itself to division of the vestibular nerve without injuring the cochlear nerve and the hearing. Even when the two branches are inseparable, an artificial though necessarily inaccurate division should easily be possible with preservation of at least the major part of the cochlear branch. Such a procedure was contemplated but was not carried out in the patient who was deaf in the other ear. Perhaps it may yet be advisable though there is no precedent on which a cure could be assured. Other experiences have shown how sensitive the auditory nerve is to trauma and even though the injury seems slight,

ficial and spontaneous remission in cases of exophthalmic goiter (figs 19, 20, 21, 22, 23, 24 and 27). The microscopic structure appeared to be that of a localized area of the parenchyma of the thyroid which presented the histologic changes characteristic of hypertrophy and hyperplasia associated with a supervening exacerbation but in this lobule there could also be seen the histologic regression and scarring characteristic of involutional changes which had occurred during a previous remission. These nodules or localized areas of hypertrophy and hyperplasia had apparently become encapsulated as a result of compression

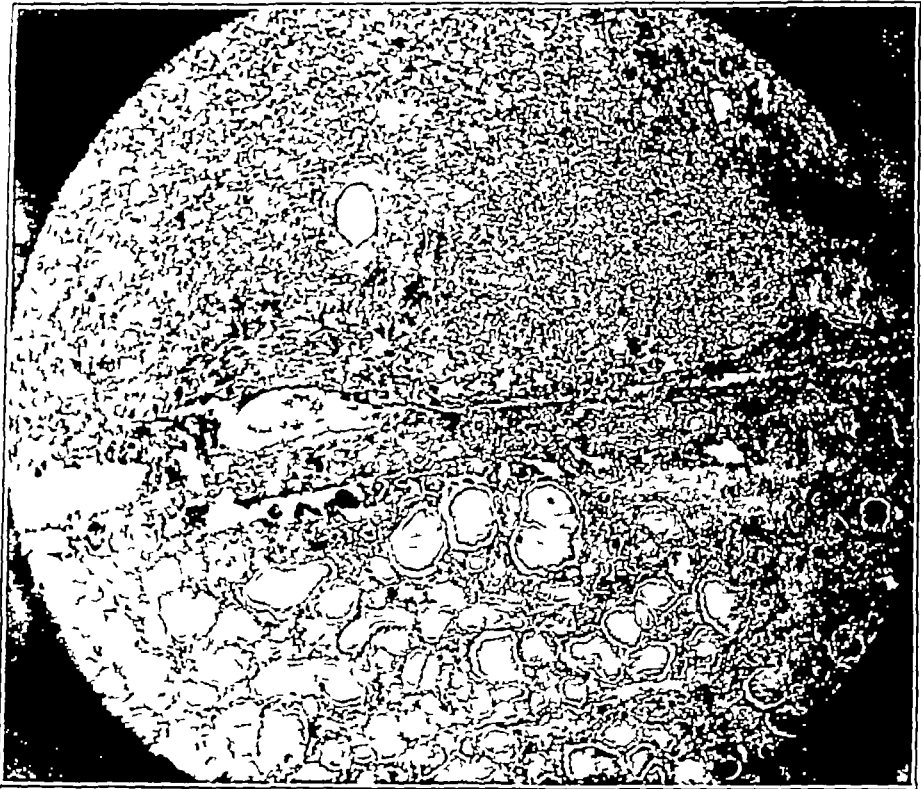


Fig 31—Section also from tumor shown in figure 26. In the upper portion of the section normal thyroid tissue can be seen separated from the localized area of hypertrophy and hyperplasia by a false or apparent capsule. This section was cut in the same manner as in figure 30 but from a different level. In the lower half of the section is shown the hyperplastic tissue composing the tumor or nodule. In this section the hyperplastic acini are more round and smaller than in figure 30 and show less infolding of the epithelium but are just as typical of hypertrophy and hyperplasia as in figure 30. This demonstrates the difference in the appearance of hypertrophy and hyperplasia of the thyroid epithelium that may occur not only in different glands or portions of the same glands but even in the same localized nodule. Reduced from a magnification of  $\times 575$ .

exerted on the connective tissue septums traversing the gland producing a chyma of adjacent lobules. Distortion of the contiguous normal thyroid tissue was apparent (figs 20, 21, 23 and 32). In between the

septa, forming the (apparent) capsule, could often be seen small groups or clusters of acini which in the majority of instances were of the normal structure, but which not infrequently presented the histologic appearance of hypertrophy and hyperplasia (figs 22, 23, 26, 29, 30, 31 and 32). Whether these areas were tongue-like diverticula from the main area of hypertrophy and hyperplasia, or whether they were the beginning of another lobule, was not determined. These islands of parenchyma demonstrated the possibility that a capsule might result from compression of the thyroid tissue and stroma surrounding these

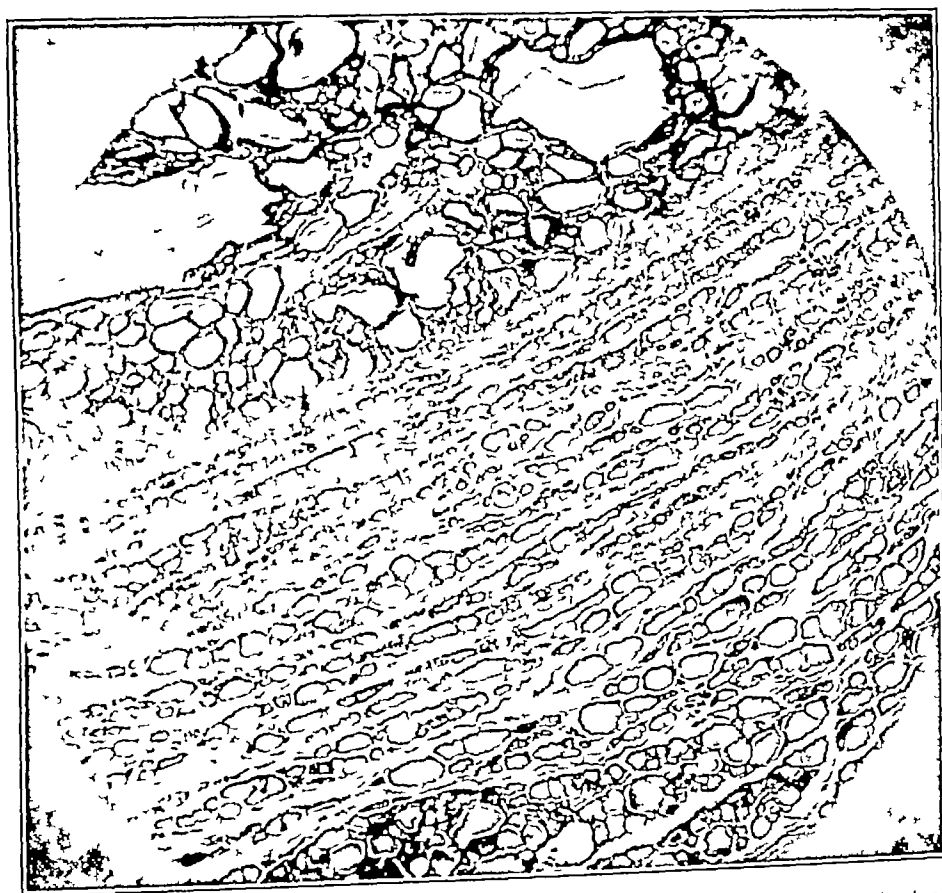


Fig 32—Section from portion of tumor shown in figure 20 demonstrating in the upper portion, the hyperplastic portion of the tumor and the peripheral compression of normal thyroid tissue and the fibrous septa, which is the forerunner of the capsule. Reduced from a magnification of  $\times 57$ .

areas of localized hypertrophy and hyperplasia. As a rule, these areas were further demarcated by a peripheral infiltration of small lymphocytes. Even if after continuing for years, the disease cycle of remissions and exacerbations had run its course, in a localized area or lobule, one would expect to find microscopic evidence of hypertrophy and hyperplasia together with those of involution (figs 27 and 28). The proportion of evidently functioning intact parenchyma to the portion showing histologic regression differed in these localized regions of

On the other hand, since in six of nine cases of true Ménière's disease there is loss of both vestibular and cochlear functions, it seems more reasonable to expect the lesion—in these cases at least—to be primary in the nerve itself rather than in the peripheral end-organs. Given the objective evidence of unilateral deafness without vestibular alteration, there are only two possible sources of the offending lesion, namely, the cochlear nerve or the cochlear end-organ. For practical purposes, the exact location does not matter. Section of the acoustic nerve should produce the same result in either point of origin. It is not improbable that the character and location of the cause may not always be the same.

#### COMPARISON OF MENIERE'S DISEASE WITH TIC DOULOUREUX AND EPILEPSY

In the symptomatic expression of Meniere's disease one is strongly reminded of other human ills, such as trigeminal neuralgia, glossopharyngeal neuralgia, and possibly of epilepsy. In all there is the same periodicity of attacks, coming on without warning and without apparent cause—all suggesting lesions of nerves or of nerve tracts or systems. In cases of neuralgia, the symptoms remain confined to the domain of the affected nerve, but in epilepsy whole systems, i e., those controlling consciousness, motor and sensory function, speech, taste and others, may be and usually are involved by the spread of the stimulus. It has been learned from experiments on animals that any cerebral defect is a potential source of epilepsy, that although the cells of the motor cortex are responsible for the remarkable phenomenon of clonic convulsions, lesions of the connecting fibers even far removed from the motor cortex, may induce attacks of precisely the same general character as when the motor cortex is involved directly. Are not Ménière's attacks in reality like seizures of epilepsy (or of trigeminal or glossopharyngeal neuralgia) differing only in that a different and independent part of the nervous system is affected? In either case any defect in the nerve circuit is always a locus minoris resistentiae removing the inhibition which holds functions under control and permitting their explosion as it were. It may be asked whether such a comparison of Meniere's disease with epilepsy is justified because in the former there is always a progressive objective loss of function (hearing). In cases of epilepsy there may or may not be progressing loss of function, the actual result depending on the character of the underlying cause, but regardless of the kind of lesion the expression of the convulsion is just the same. The same is true of trigeminal or glossopharyngeal neuralgia. The characteristic ticlike pain is precisely the same whether a tumor is the offending cause or whether the cause escapes the present inadequate tests.

It is useless to speculate further concerning the character of the lesion causing Meniere's disease, or its precise location within the limits

## MICROSCOPIC ANATOMY OF THE NERVES THAT LEAD TO THE LUNGS

Numerous investigators have carried out extensive studies on the microscopic course of the nerve fibers to the lungs. Brauer<sup>11</sup> reviewed the work of the various investigators in detail, therefore we shall mention only the conclusions which were reached by their studies. Van Gehuchten and Molhant<sup>12</sup> showed that the bronchomotor fibers of each vagus have their origin in the dorsal nucleus of that nerve, and from that nucleus they extend without interruption to the hilum of each lung. It is still undetermined whether or not these fibers are interrupted in the peripheral ganglions of the lungs, but most investigators agree that it is probable that such an interruption actually takes place. The experimental evidence in favor of this assumption can be found in the report of Molhant<sup>12</sup>. He succeeded in completely removing one lung in two young dogs without producing any degeneration of the cells in the dorsal nucleus of either vagus nerve. In these same dogs, he found many degenerated nerve cells in the middle cervical sympathetic ganglion on the side where he had previously performed the pneumectomy. Only a few degenerated cells were found in the middle cervical ganglion of the opposite side. Further studies on the same animals failed to show any direct connection between the nerves to the lungs and the spinal cord. The cells in the stellate ganglions did not show any changes, although a few nerve cells showing marked chromolysis were found in the second and third thoracic sympathetic ganglions.

In similar experiments on cats Molhant<sup>12</sup> showed that most of the degenerated nerve cells were found in the stellate ganglions. The middle cervical ganglions are not always present in that animal, but in those animals in which the ganglions were present there was some degeneration of the nerve cells in them following pneumectomy.

From the foregoing experiments, we may draw the following conclusions. There are fibers which go directly from the dorsal nucleus of each vagus to the hilum of the corresponding lung where they are interrupted for the first time in the peripheral ganglions of that lung. The middle cervical and stellate ganglions, together with the second and third thoracic sympathetic ganglions, constitute the sympathetic centers of the lungs (fig. 5).

*The Possibility of Denervating One Lung*—After a careful consideration of all the data which we have presented on the macroscopic and microscopic course of the nerves leading to the lungs, the ques-

13 Van Gehuchten, A., and Molhant. Contribution a l'etude anatomique du nerf pneumogastrique chez l'homme, Bull Acad roy de Belgique 25 859, 1911.  
14 Molhant, H. Studien über das respiratorische Nervensystem bei den Wirbeltieren, Skandin Arch f Physiol 26 315, 1912.

just defined Frankl-Hochwart mentioned leukemia, syphilis, rheumatism and trauma as predisposing causes and reported cases to support this statement. Recently I saw a patient (not included in this report) afflicted with Menière's disease and with proved syphilis of the nervous system. In none of the nine cases in this report has there been any of the predisposing causes mentioned by Frankl-Hochwart. The uniform absence of a history of otitis media or of mastoid infection, or of a positive Wassermann reaction from the blood is worthy of note.

It would seem that the treatment in cases of true Ménière's disease by section of the eighth nerve has precisely the same rationale as section of the sensory root of the trigeminal or glossopharyngeal nerves in tic douloureux. If the attacks begin either in the eighth nerve or in the cochlea—and they begin in one or the other—and if the lesion is strictly unilateral, impulses can no longer be transmitted after section of the nerve. It is then hardly conceivable that future attacks are possible after section of the eighth nerve. Moreover, since section of the nerve is central to the ganglionic cells in the semicircular canals and cochlea, regrowth of the nerve and recurrence of the attacks should be precluded. If these impressions and deductions are correct, section of the eighth nerve should serve as a therapeutic test of Menière's disease just as section of the trigeminal sensory root or of the glossopharyngeal nerve are tests for tic douloureux of these nerves.

#### SUMMARY AND CONCLUSIONS

1 Intracranial section of the affected eighth nerve is suggested as a cure for Menière's disease. This operation has been performed on nine patients, none of whom has had a subsequent attack. The elapsed time since operation varies from three months to three and one-half years.

2 The operation should be attended by no mortality and with no after-effects, since the patients are practically deaf in the affected ear before operation.

3 Although the series of cases is small, the results suggest that section of the acoustic nerve should stop Menière's attacks just as absolutely as intracranial section of the glossopharyngeal nerve or of the sensory root of the trigeminus stops the attacks of tic douloureux in these two nerves.

4 The symptoms and signs of Ménière's disease are analyzed. The dizziness of Menière's and pseudo-Menièr's diseases are compared with that of other known lesions—tumors, inflammations and aneurysms—in the cerebellum and brain stem.

5 There appear to be reasons to doubt that the cause of Menière's disease is primary in the semicircular canals. A primary lesion of the acoustic nerve seems a more probable primary source of the attacks.



tion arises as to the possibility of completely denervating the lungs of an animal for experimental purposes. Our studies have been made on dogs because the innervation of the lungs in that animal is the most constant, and also because of the accurate data on the anatomy and physiology of the nerves to the lungs that is available

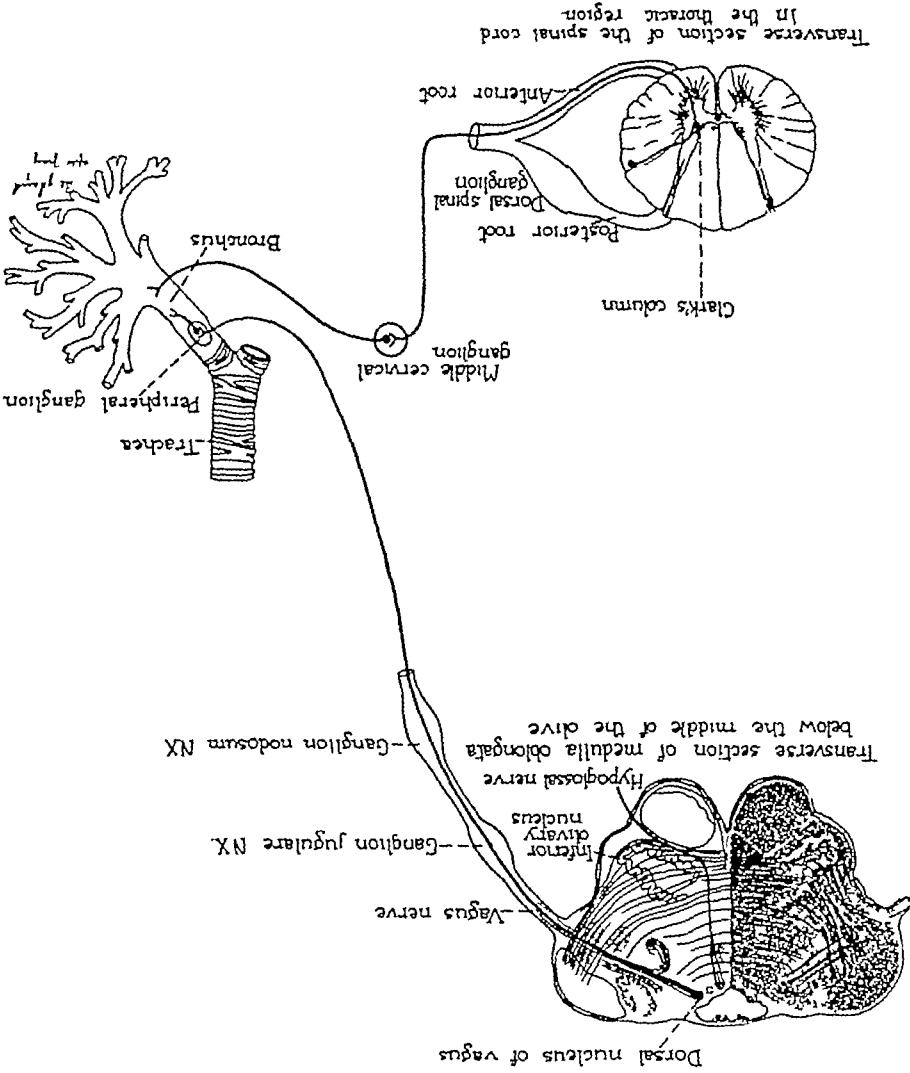


Fig 5—Diagram showing the course of the efferent sympathetic nerve fibers to the lung from the nuclei in the medulla oblongata by way of the vagus nerve, and from the nuclei of Clark's column in the spinal cord by way of the thoracic ramus communicans

From the theoretical standpoint, the lungs can be denervated by two different methods. The first method consists of the removal of all the sympathetic branches to the lung, as well as the removal of a section of the vagus nerve on the same side. The second method consists of the removal of the fibers from the peripheral plexuses at a point just before they enter the hilum of the lung

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The sympathetic fibers to the lungs come from the spinal cord by way of the superior thoracic rami communicantes. The fibers then enter the stellate ganglion and pass through the ansa Vieussens into the middle cervical ganglions. From there they reach the lungs through the anastomoses which these ganglions have with the recurrent laryngeal and the inferior tracheal nerves, the aortic plexus and the inferior cardiac nerves. Consequently, below the ganglions the pulmonary fibers of the sympathetic trunk are much scattered, and it is difficult to isolate and identify them during any surgical procedure. These fibers are confined to definitely recognizable nerves only in the region of the ganglions, and it is in this region that they should be severed during the operative procedure. Similar results can be accomplished by cutting the rami communicantes of the last cervical and the first seven thoracic sympathetic ganglions. The method of multiple ramisection described by von Gasa<sup>15</sup> would make this procedure an easy one, but, as we have shown, the ramisection would not eliminate the fibers from the various ganglions. Mollgaard<sup>11</sup> showed by his experiments that these ganglions are important centers, and that they are able to function even after they have been completely separated from their central connections. Consequently, we believe that it would be necessary to remove completely the middle cervical ganglion, the stellate ganglion, and the second, third, and fourth thoracic sympathetic ganglions in order to interrupt the direct pathway of the nerves to the lung. In the dog, however, the middle cervical ganglions are usually within the common vagosympathetic trunks, therefore, in order to remove them completely, it is necessary to remove a section from each of the vagosympathetic trunks. It is only in rare cases that the middle cervical ganglions can be separated from the common vagosympathetic trunks. From the experimental standpoint, this fusion of the middle cervical ganglions with their corresponding vagosympathetic trunk is important, since the removal of that ganglion necessitates the removal of a section of the vagus nerve on that side and consequently removes that vagus as a source of nerve supply of the lungs. On each side just above the middle cervical ganglion the recurrent laryngeal nerve becomes separated from the vagus. Thus, by removing a section of the common vagosympathetic trunk for a distance of 1 cm on either side of the middle cervical ganglion, we simultaneously interrupt the two main nervous pathways to that lung.

From our study of these nerves, we conclude that in order to eliminate simultaneously and as completely as possible the vagus and

15 V Gasa, W. Die Resektion der paravertebrealen Nerven und die Isolierung der Durchschneidung des Ramus communicans, Arch f klin Chir 133 479, 1924, Klin Wchnschr 25 525 1924

# EXPERIMENTAL STUDIES ON DENERVATED LUNGS\*

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There is no vital structure in the body that is so frequently the seat of disease as the lung, still the practical importance of the innervation of this organ is not generally appreciated. The complexity and often the contradictory evidence regarding this innervation have prevented the real facts from being disseminated even in medical schools. Recent evidence, however, emphasizes the important rôle which the nerves that lead to the lung may play in clinical disorders. Binger and his associates<sup>1</sup> have shown that the tachypnea which accompanies acute pulmonary disease in the absence of anoxemia is of nervous origin. The cause of sudden death in cases of pulmonary embolism and following thoracentesis, as well as the cause of bronchial asthma and allied conditions, may also be nervous in origin. It has also been suggested that postoperative massive atelectasis (collapse) of the lungs may, in part, be due to a disturbed innervation. Our interest in this matter arose from the hope that following experimental alterations in the nerves that lead to the lungs we might be able to reproduce the latter condition. Our studies deal with the possibility of complete denervation of the lungs, the methods used to produce partial denervation of one lung and the changes in the physiology of respiration that were produced by such denervation. Before entering into the details of this study, it seems wise to outline briefly the anatomy and the histology of the nerves to the lungs.

## MACROSCOPIC ANATOMY OF THE NERVES TO THE LUNGS

In man, the bronchi and the lungs receive their innervation from the plexuses of nerves which surround the bronchi in the region of the hilum of each lung (fig 1). These plexuses are made up of fibers from the vagal nerves and the cervical sympathetic trunk of the corresponding side, schematically, they may be divided into two main plexuses called the anterior and the posterior pulmonary plexuses. It

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<sup>1</sup> Binger, C A, Boyd, D, and Moore, R L. The Effect of Multiple Emboli of the Capillaries and Arterioles of One Lung, *J Exper Med* **45** 643, 1927.

the sympathetic part of the innervation of one lung, it is necessary to resect the first four thoracic sympathetic ganglia to remove the ansa Viesseni and the stellate ganglion, and to resect that portion of the vagosympathetic trunk which has included in it the middle cervical ganglion. All this should be done on the side on which the denervation is to be accomplished.

METHODS FOR SECTIONING THE EXTRINSIC NERVES OF ONE LUNG

The sectioning of the extrinsic nerves of one lung may be done either by the cervical or by the intrathoracic approach.

*The Cervical Approach*—In several dogs we succeeded in removing the stellate ganglion by using a cervical approach which was similar to the one outlined by Professor Leriche<sup>16</sup> for the extirpation of that ganglion in man. The approach was made through a low cervical incision just behind the anterior border of the sternocleidomastoid muscle. The stellate ganglion lies immediately beneath the vertebral artery and can be readily exposed by a slight anterior retraction of that artery. From this incision, it is also possible to remove without much difficulty that section of the vagosympathetic trunk which has included in it the middle cervical ganglion. The cervical approach, however, makes the resection of the third and fourth thoracic sympathetic ganglia practically impossible. As we have shown, these thoracic ganglia have numerous important connections with the nerves that lead to the lungs, consequently, those pathways must be interrupted if we hope to produce the denervation of one lung. It is because of this difficulty that we have used the transthoracic route in our studies on dogs.

*The Transthoracic Approach*—In man, the thoracic sympathetic ganglia and trunks can readily be reached by an extrapleural approach similar to the operation proposed by Torek<sup>17</sup> for the exposure of the thoracic part of the esophagus. In dogs, however, the extrapleural route would necessitate a long and difficult operation. In our experience, the transthoracic approach is well tolerated by the dogs and it overcomes many of the technical difficulties that are encountered in the other procedures.

#### TECHNIC OF OPERATION

The dog is first completely anesthetized by the drop ether method and then a large soft rubber catheter is inserted into the trachea and artificial respiration is instituted by means of the Ljungström insufflation apparatus. The amount of

16 Leriche R. De la découverte du ganglion étoilé de ses opérations qui se pratiquent à ce niveau, Lyon Chir. 23 763, 1926.  
 17 Torek Franz. The Operative Treatment of Carcinoma of the Esophagus, Ann Surg 61 385 1915. Carcinoma of the Thoracic Portion of the Esophagus, Arch Surg 10 353 (Jan) 1925.

has been shown that there is a rich anastomosis between the fibers of the plexuses on the same side as well as between the fibers from the corresponding group on the opposite side

*The Branches of the Vagi that Lead to the Lungs*—The majority of the fibers from the vagi come from the intrathoracic portion of that nerve, while only a few come from the inferior cardiac and

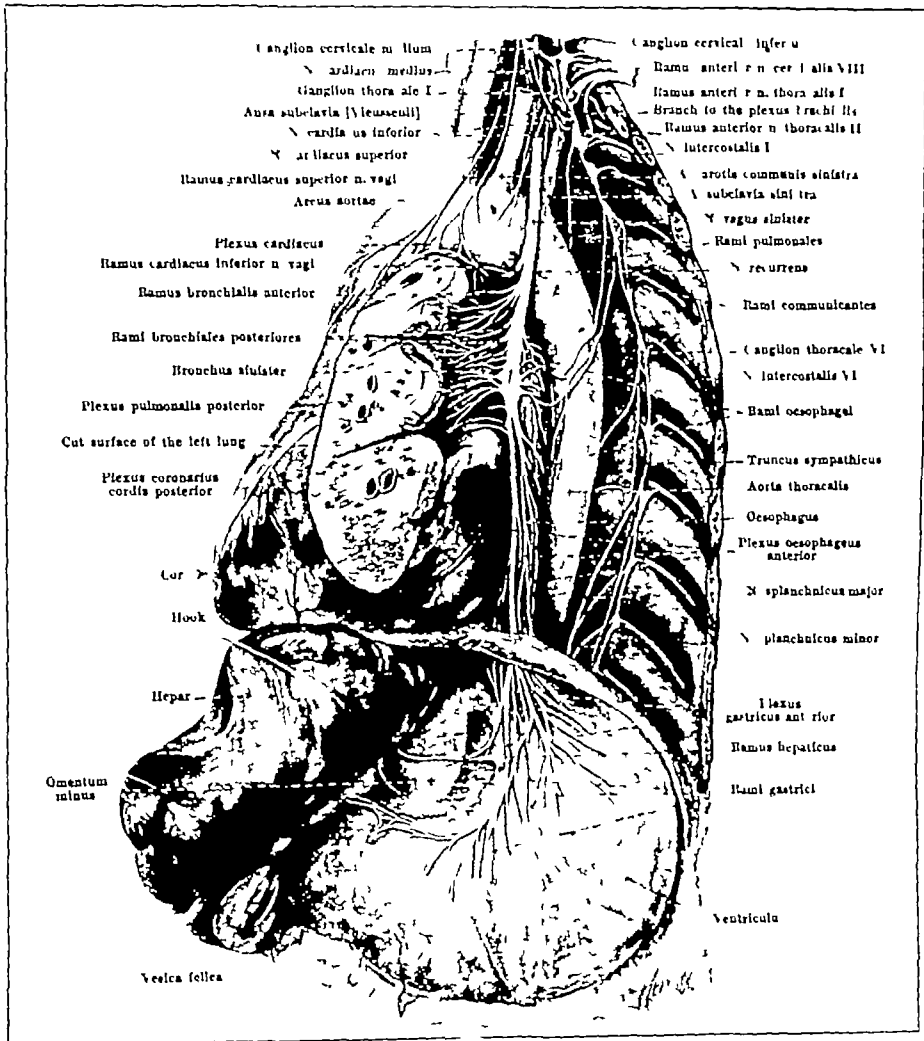


Fig 1—The course and branches of the left vagus nerve in the thoracic and abdominal cavities of man (from Spalteholz Atlas, ed 4)

recurrent laryngeal nerves. The branches from the latter nerves, however, vary greatly in number and in size. From a gross anatomic standpoint, the fibers from the vagal nerves are much more numerous than those from the sympathetic trunks. Hovelacque,<sup>2</sup> in his recent

2 Hovelacque, A. Anatomie des nerfs craniens et rachidiens et du système grand sympathique chez l'homme, Paris, Doin, 1927, vol 1, p 232

ether vapor in the system is regulated so that the animal is kept well anesthetized during the entire operation. The dog is then placed on its right side, and the operative field is thoroughly cleansed with alcohol and 1:5,000 mercuric chloride solution. After the sterile linen draping has been applied, an incision about 10 cm in length is made in the second intercostal space. The incision is carried to the parietal pleura, after which the bleeding vessels are carefully clamped and tied with silk. The parietal pleura is then incised, and the upper lobe of the left lung is retracted to obtain a good exposure in the region of the angle of the second rib. The sympathetic trunk is then visible through the posterior parietal pleura. This pleural covering is incised, and the sympathetic trunk is dissected out to a point well below the fourth thoracic sympathetic ganglion (fig 6). All the rami of the upper four thoracic ganglia, as well as the ramus

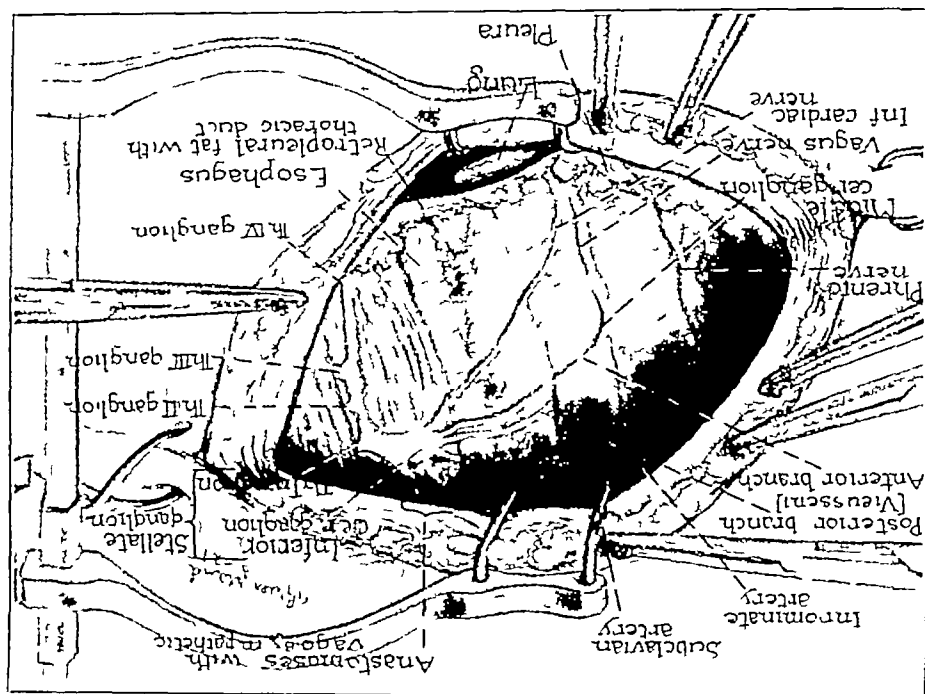


Fig 6—Exposure of the stellate ganglion and its branches by the trans-thoracic route

of the stellate ganglion are isolated. The excision is begun from below, the sympathetic trunk below the fourth thoracic ganglion being severed first. After all the branches of the fourth, third and second thoracic ganglia have been severed, the lateral branches of the stellate ganglion are isolated and severed. The stellate ganglion is dissected out and the anterior and posterior branches of the ansa Vieussens are identified and freed. These branches are respectively on the anterior and posterior aspect of the subclavian artery. The posterior branch is cut and the anterior branch is followed to its junction with the middle cervical ganglion in the common vagosympathetic trunk (fig 7). The portion of the vagosympathetic trunk which has included in it the middle cervical ganglion as well as the origin of the recurrent laryngeal nerve is then completely resected. Hemorrhage during this procedure is practically negligible. Two fine silk sutures are used to approximate the edges of the posterior parietal pleura at the site of the operation. The anterior parietal pleura is closed by

book, stated that each vagus sends the following branches to the lungs and bronchi

1 The tracheal branches which form a plexus that surrounds the trachea and both primary bronchi

2 The anterior pulmonary branches which arise from a small branch of each vagus in its intrathoracic suprabronchial course. The end branches of these nerves enter the hilum of the lungs on the anterior side of the pulmonary vessels. Taft<sup>3</sup> stated that frequently the anterior pulmonary branches arise from the middle, but more constantly from the inferior cardiac nerves

3 The bronchopulmonary nerves consist of from four to six branches from the main trunk of each vagus. The branches unite to form the anterior and the posterior pulmonary plexuses. Some of these fibers enter the bronchial wall immediately, but the majority follow the posterior wall of the primary bronchi and enter the hilum of the corresponding lung. At this point some of the fibers leave the bronchial wall and course between the visceral pleura and the pulmonary parenchyma for a considerable distance. Other branches from the same plexuses follow the course of the pulmonary veins, and according to Cruveilhier,<sup>4</sup> frequently a small branch is found on the posterior side of the pulmonary arteries

*The Sympathetic Branches that Lead to the Lungs*—There is a rich anastomosis between the sympathetic fibers and the fibers from the vagi so that many of the sympathetic fibers also enter into the formation of the pulmonary plexuses. In general, however, the majority of the sympathetic fibers come from the inferior cervical ganglions and from the first four thoracic sympathetic ganglions. In addition, there are a few fibers from the cardiac nerves which go to the lungs by way of the bronchi and a still smaller group of fibers that accompanies the bronchial arteries

*The Peripheral Ganglions*—In 1840, Remak<sup>5</sup> described the numerous separate ganglions which are interlaced between the fibers that make up the pulmonary plexuses. Later Schiff,<sup>6</sup> Kolliker,<sup>7</sup> Toldt,<sup>8</sup> and Kandarazki<sup>9</sup> showed that these ganglions vary greatly in size and in number, but they are always numerous along the bronchi near the hilum

3 Taft, cited by Hovelacque (footnote 2)

4 Cruveilhier, cited by Hovelacque (footnote 2)

5 Remak, R., *Ztschr. d. Verhandl. f. Heilk.*, 1840

6 Schiff, *Arch. f. Physiol. Heilk.* 6:792, 1853

7 Kolliker, *Arch. f. mikr. Anat.* 2:320, 1854

8 Toldt, Carl, *Lehrbuch der Gewebelehre mit vorzugsweiser Berücksichtigung des menschlichen Körpers*, ed. 3, Stuttgart, 1888

9 Kandarazki, M., *Ueber die Nerven der Respirationswege*, *Arch. f. Anat. u. Entwicklungsgesch.* 1:11, 1881



a continuous fine silk suture. The intercostal muscles are closed with interrupted chromic catgut sutures. Just before the second row of interrupted sutures are tied, a hemostat is inserted between the ribs into the pleural cavity. The hemostat is used to spread the soft tissues, and the lungs are inflated to expel the air from the pleural cavity. The subcutaneous tissues are brought together by interrupted silk sutures, and the edges of the skin are approximated in a similar manner.

If peripulmonary sympathectomy is to be performed at the same time as the foregoing procedure, it is better to make the incision in the third intercostal space, since this approach gives a better exposure of the pulmonary artery and

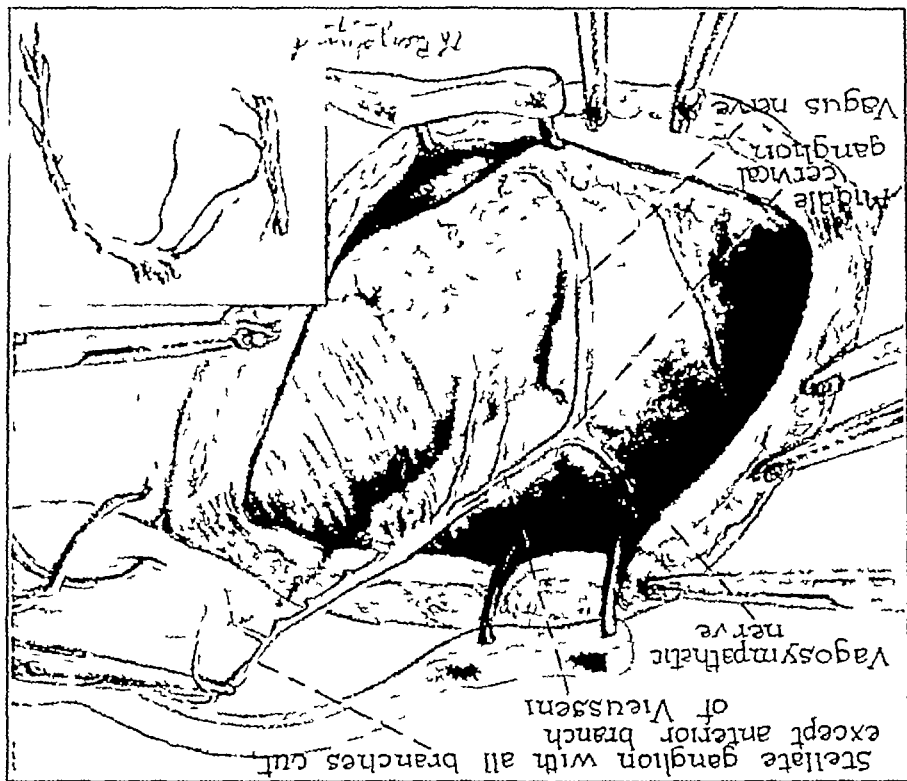


Fig 7—Method of resecting the stellate ganglion and its branches. The anterior branch of the ansa Vieussens is used as a guide to the middle cervical ganglion which is included in the common vagosympathetic trunk.

does not make the resection of the stellate ganglion and its branches any more difficult. We have used the latter procedure on three dogs with satisfactory results.

*Comments on the Operative Procedures*—The question arises as to the possibility of producing a complete denervation of one lung. It one recalls the macroscopic and microscopic studies of the nerves that lead to the lungs, one sees that even after such extensive operations as we have already described there are still two sources of nervous impulses that have not been interrupted. The first source is from the ganglions that are situated within the bronchial walls, while the



other source is by way of the fine anastomotic fibers from the pulmonary plexuses of the opposite side. Hence, we must conclude that this surgical procedure does not produce a complete denervation of one lung when the procedure is performed on only one side. In the studies which we were interested in making, it was necessary to keep the nerve supply of one lung intact in order that the reaction of the partially denervated lung could be compared with its normal mate. For this reason, bilateral extirpation of the nerve trunks to the lungs was not used in any of the experiments which we report here. However, even after bilateral extirpation of these nerves there would still be one source of nervous impulses to the lungs, namely, the peripheral ganglions that are situated in the walls of the trachea and bronchi.

Theoretically, it is possible to produce a complete denervation of one lung by removing all the fibers that make up the peripheral pulmonary plexuses on one side. These plexuses, as we have shown, contain all the sympathetic and vagal fibers for one lung. Technically, this is an extremely difficult procedure, since the fibers are so numerous and some of them are so fine that we can never be certain that all the fibers have been interrupted. We have attempted this procedure on several dogs, but after killing the animals and carefully examining the site which had previously been occupied by the pulmonary plexuses, we invariably found several fibers that had not been severed during the operation. We have also tried to denervate one lung by bronchial denudation, but this procedure is likewise an uncertain one in regard to complete interruption of all the nervous pathways to that lung.

#### RESULTS OF THE STUDIES ON DOGS IN WHICH THE EXTRINSIC NERVES OF ONE LUNG HAD BEEN SEVERED AT OPERATION

A series of ten dogs in which the extrinsic nerves to one lung had been severed was used for these studies. The dogs were observed over periods varying from several weeks to several months and the data which we obtained may be grouped under the following five headings: *Effect on the Respiratory Movements*—The frequency and character of the respiratory movements were charted for several days prior to the operation, and a normal respiratory curve for that animal was plotted. For several weeks following the operation a similar record was kept. In analyzing the various curves, it was found that there was no constant change in the respiratory movements after the extrinsic nerves to one lung had been severed. Likewise, the rate or volume of the pulse following the operation was not altered, the immediate postoperative reaction which usually lasted for a few hours is excluded.

man and in the various experimental animals, yet when we consider all animals in one group we find that there is more variation in the fibers from the sympathetic trunks than there is in the fibers from the vagi. It has been only within recent years that the exact anatomy of the nerves leading to the lungs of the various experimental animals has been worked out. Braeucker<sup>11</sup> added much information to this subject by his work on dogs.

In the dog the nerve supply of the lungs is likewise derived from the vagi and from the cervical sympathetic trunks (figs 2 and 3). The fibers from the vagi reach the lung by two main routes, namely,

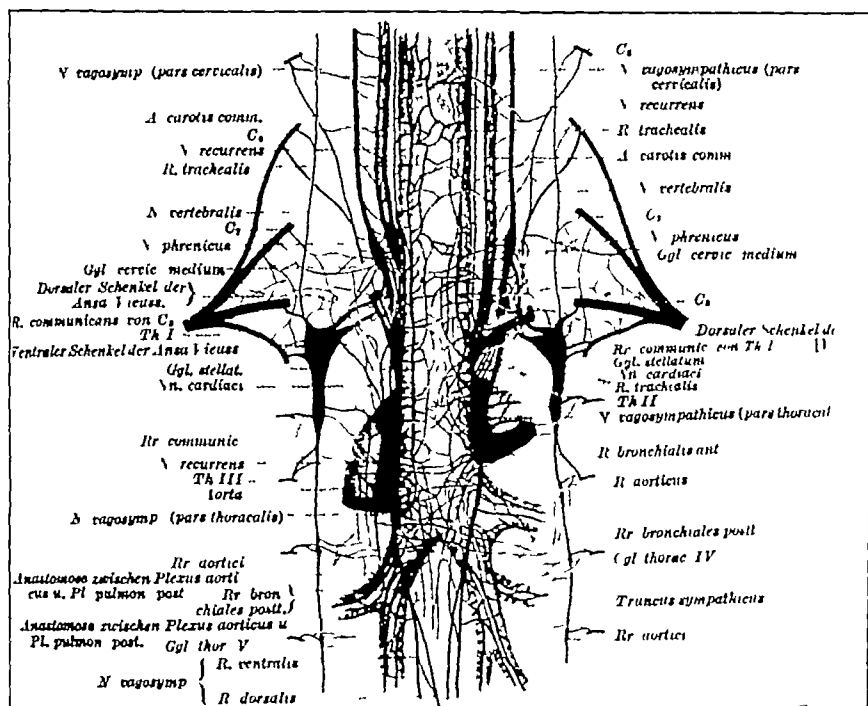


Fig 3—Posterior view of the nerves from the tracheobronchial trunks in the dog (from Braeucker<sup>11</sup>)

by the anterior bronchial nerves and by the posterior pulmonary nerves. The former are branches of the inferior tracheal nerves which come from the vagi through the recurrent laryngeal nerves. The posterior pulmonary nerves consist of from four to nine distinct fibers. Three of these fibers are usually well developed and arise from each vagus at the inferior border of the primary bronchi. The branches of the nerves surround the major bronchi and form the posterior pulmonary plexuses. Scattered between the nerve fibers are

<sup>11</sup> Braeucker, W. Die experimentelle Erzeugung des Bronchialasthmas und seine operative Beseitigung, Arch. f. klin. chir. **137**: 463, 1925, *ibid.* **139**: 1, 1926.

*Effect on the Carbon Dioxide Combining Power of the Blood Plasma.*—These determinations were made according to the method of Van Slyke and Neil<sup>18</sup>. From the table it is evident that there was not a constant variation in the results following the operation. The slight diminution which followed immediately after the operation usually returned to normal within two days. In some of the dogs, there was a slight increase which persisted over a period of several weeks, but this increase was so slight that it never exceeded the limits of normal variation. The table illustrates the average variation in three different animals as well as the reaction which follows the operation.

*Effect of Various Kinds of Experiment Embolus.*—In this series of experiments, we compared the reaction of a partially devascularized lung with that of its normal mate after various kinds of experimental emboli had been injected into the general circulation by way of the external

Reactions in the Carbon Dioxide Combining Power of the Blood Plasma Before and After Partial Devascularization of One Lung

Dog "West"		Dog "West"		Dog "West"	
Date	Blood (cc)	Date	Blood (cc)	Date	Blood (cc)
May 28	10.11	June 13	53.30	July 7	17.13
Preoperative embolism for control		Preoperative embolism for control		Preoperative embolism for control	
May 11	15.10	June 17	61.28	July 11	11.11
June 1	18.13	June 21	61.01	July 11	11.52
June 1	17.82	June 21	61.17	Aug. 6	52.10
June 7	53.11	July 7	61.27		

\* Per cent, combined at 0° centigrade and 760 mm. pressure

jugular vein. In several of the dogs of this series, we injected 10 cc. of a thick suspension of lycepodium in a saline solution into the left jugular vein. One month after the original injection, the same procedure was repeated and the dog was killed three days later. Similar experiments were performed with a medium suspension of potato starch cells in saline solution. The general results were the same in both groups of animals. At autopsy numerous small yellow spots were found distributed equally throughout both lungs. Microscopically, the small yellow areas were shown to be small abscesses. There was no difference between the abscesses in the partially devascularized lung in comparison with those in the lung which the nerve supply remained intact (fig. 9).

*Effect on the Gross and Microscopic Anatomy of the Lung.*—The microscopic and macroscopic studies of the lungs of dogs that were killed at various lengths of time after the section of the extrinsic nerves

<sup>18</sup> Van Slyke, D. D. and Neil, J. M. quoted by Michael, J. R. *Physiology and Biochemistry in Modern Medicine*, ed. J. St. Louis, C. V. Mosby, 1922, p. 12, J Biol Chem 61 513, 1924

numerous ganglions of various sizes. The anastomosis with the fibers from the opposite side takes place largely by way of the inferior tracheal nerves. The majority of the sympathetic fibers reach the lung by an indirect route. Some of the sympathetic fibers are distributed to the lungs through the subclavicular plexuses. These plexuses are made up of fibers from the middle cervical<sup>12</sup> and stellate ganglions, from the posterior branch of the ansa Vieusseni and from the rami communicantes of the seventh cervical and the first thoracic ganglions.

Other sympathetic fibers go to the lungs by way of the recurrent laryngeal and the inferior tracheal nerves. Part of these fibers come directly from the middle cervical ganglions, and part of them course through the inferior cardiac nerves. The fibers from the recurrent laryngeal, the inferior tracheal and the inferior cardiac nerves are all grouped together to form the anterior pulmonary plexus, particularly on the right side. The inferior cardiac nerve on that side is made up of two branches from the right vagosympathetic trunk, one branch from the recurrent laryngeal nerve, one from the anterior loop of the ansa Vieusseni, one from the left middle cervical ganglion, one from the left recurrent laryngeal nerve, and one from the left vagosympathetic trunk. All these nerves have a rich anastomosis with both stellate ganglions and the upper thoracic rami communicantes of both sides.

On the left side, the aortic plexus sends numerous fibers to the pulmonary plexuses. The aortic plexus is made up of fine branches from the upper thoracic rami communicantes of both sides (fig. 4).

In the dog, the general distribution of the peripheral ganglions in the walls of the trachea and the bronchi is essentially the same as we have already described for man, consequently, we shall omit the repetition.

In general, there are two groups of nerves which contribute to the innervation of the lungs. The first group consists of fibers from the vagi which course through the bronchopulmonary and the recurrent

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<sup>12</sup> Braeucker,<sup>11</sup> in his work on the dog, has shown that the ganglion which is included in the common vagosympathetic trunk is in reality the middle cervical ganglion and should always be referred to by that name. Many other investigators, however, refer to that ganglion as the inferior cervical ganglion. We agree with Braeucker that the ganglion which receives the last cervical ramus communicans should be called the inferior cervical ganglion, and the ganglion which receives the first thoracic ramus communicans should be called the first thoracic sympathetic ganglion. In man as well as in the dog, the real inferior cervical ganglion is usually fused with the first thoracic ganglion and it is this association that should be called the stellate ganglion. For this reason the middle ganglion should always be called the middle cervical ganglion, in spite of the fact that it sometimes lies deep in the thorax, even as low as the second rib.

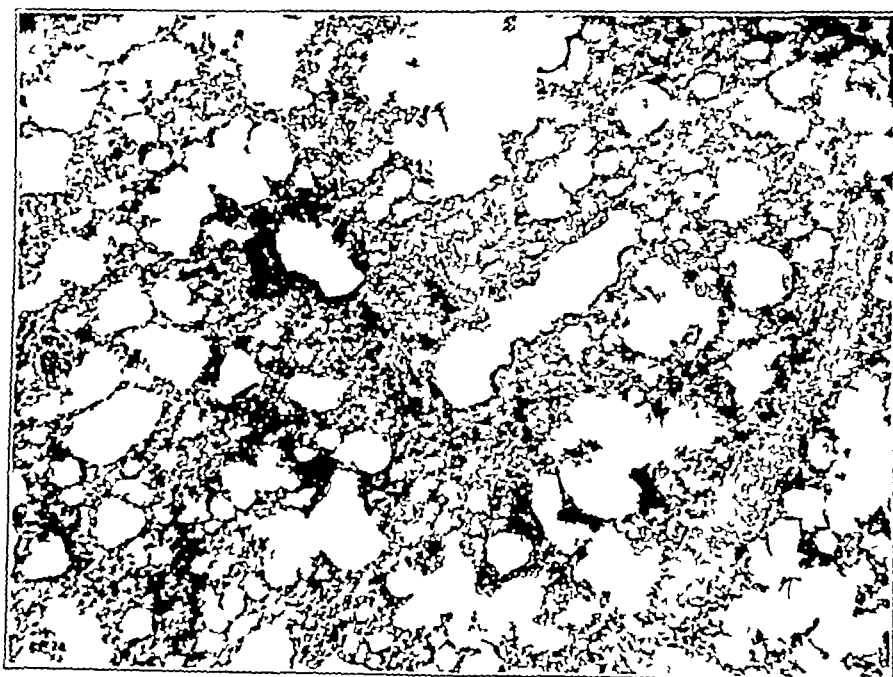


Fig 8—Photomicrograph of a section taken from the right lung of a dog in which a suspension of lycopodium and acacia had been injected into the left jugular vein three days previously. Numerous small abscesses were present throughout the entire lung,  $\times 100$ .

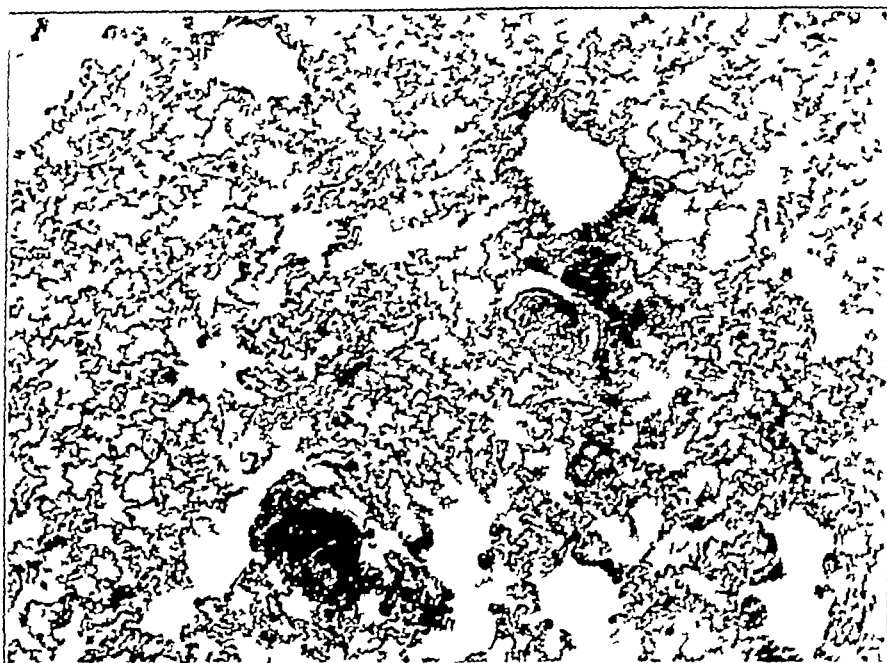


Fig 9—Section from the upper lobe of the partially denervated left lung of the same animal as figure 8, showing similar small abscesses,  $\times 100$ .

laryngeal nerves The other group of fibers comes from the middle cervical and the stellate ganglions of the sympathetic trunks by way of the inferior cardiac nerves and by way of the ansa Vieusseni There are also several small branches which go directly from the thoracic ganglions to the lungs along the course of the bronchial arteries In the dog, the bronchopulmonary innervation comes from two major plexuses, namely, the anterior pulmonary plexuses and the

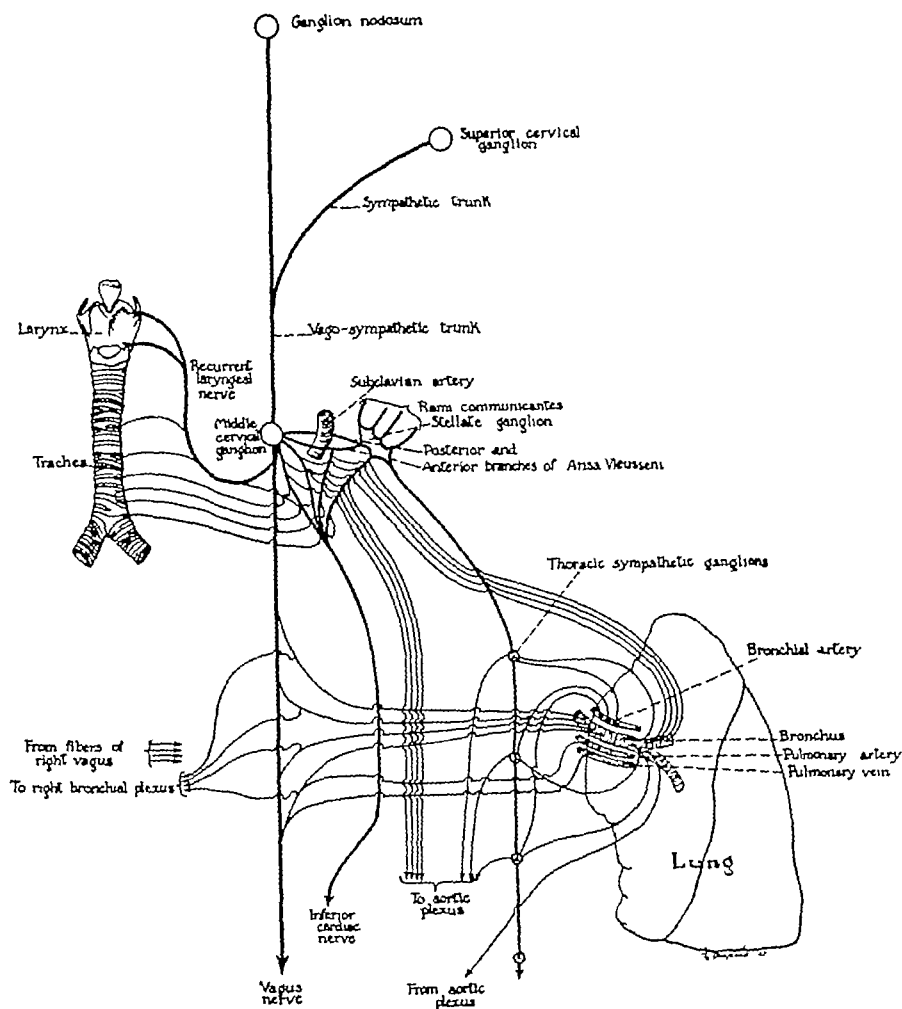


Fig 4—Diagram showing the origin of the various sympathetic nerve fibers which go to the left lung of the dog

posterior pulmonary plexuses The former are made up of branches from the inferior cardiac nerves together with the inferior tracheal branches of the vagus nerves The posterior pulmonary plexuses contain only fibers from the vagi There is a rich anastomosis, however, between the two plexuses as well as between these plexuses and the tracheal and pulmonary plexuses of the opposite side On the left side, the anterior pulmonary plexus receives fibers directly from the aortic plexus (fig 4)



to one of the lungs did not show any evidence of changes from the normal. In two of the dogs a few adhesions were found between the lung and the healed operative wound. In none of the dogs were we able to find any evidence of congestion, edema or other pathologic change.

*Massive Atelectasis (Collapse) in a Partially Degenerated Lung—* One of our dogs developed a typical massive atelectasis (collapse) of the lungs three days after we had severed the extrinsic nerves to the left lung. The immediate postoperative course of this dog was entirely normal. Studies of the carbon dioxide combining power of the blood plasma both before and after the operation did not show any variation from the normal. The frequency and character of the respirations prior to the occurrence of the massive atelectasis were normal. There was no evidence of inflammation about the operative wound. The dog had been active and apparently had not suffered any ill effects from the operation. The animal was placed on the operating table for the purpose of obtaining a specimen of blood for the estimation of the carbon dioxide combining power of the plasma. The dog was quickly turned on its back and immediately became deeply cyanotic, respirations ceased within a short time, and finally the heart ceased beating. A roentgenogram of the chest taken at this time showed the diaphragm on the left side to be higher than it had been on the previous control roentgenograms. Displacement of the mediastinum was not demonstrable in the roentgenograms.

Autopsy revealed a typical massive atelectasis (collapse) of the entire left lung and a partial atelectasis of the lower lobe on the right side. The operative wound was entirely healed. The upper part of the right lung appeared normal. Free fluid was not found in the pleural cavities. In the dog, the mediastinal membrane which separates the two pleural cavities has been shown by Alatas<sup>19</sup> and others to be delicate, it is, therefore, fair to assume that when an acute condition such as massive atelectasis occurs on one side, the physical signs which characterize this condition in man may not occur, if the mediastinal membrane ruptures before the heart can be drawn to the affected side. The rupture of this interpleural membrane may explain the difference between the clinical picture of massive atelectasis (collapse) of the lung in man and in the dog.

Macroscopically, all the major and minor bronchi were dissected out but evidence of obstruction could not be found. The bronchi were normal in appearance and contained practically no secretion. One of the lobes of the collapsed lung was resuscitated, and the pulmonary

19 Alatas Rudolph So-called Mediastinal Septum of Dog in Relation to Pneumothorax Problem in Min Arch Surg 8 336 (Jan) 1924

hyperplasia and hypertrophy. In the younger patients the evidence of histologic regression was less pronounced, and almost the entire nodule was composed of tissue of the normal structure of the thyroid which had undergone hypertrophy and hyperplasia. In the older patients with cases of long standing there was a more marked degree of histologic regression, so that the nodules although much larger about the size of a lemon, were composed almost entirely of fibrous tissue, extra-acinar colloid from disintegrated acini and a few scattered acini still remaining intact, surrounded by a small peripheral rim of hyperplastic parenchyma (figs 27 and 28). This condition in the older patients was probably due to the greater frequency of the completion of the morbid cycles and the consequent gradual reduction of the parenchyma due to the process of involution that accompanied each remission. Thus, it is conceivable that if a sufficient number of the disease cycles were completed, there would eventually be an entire loss of function in that region in which substitution of the parenchyma by fibrous tissue had occurred (figs 25, 27 and 28).

The parenchyma intervening between these localized areas of hypertrophy and hyperplasia was normal thyroid tissue in all respects (figs 19, 20, 22, 23, 24, 29, 30, 31 and 32). As it was evident (1) that the patients had a clinically apparent hyperthyroidism (2) that this was associated with a goiter in which the nodular elements were composed of localized areas of thyroid parenchyma presenting the characteristic histologic appearance which has come to be recognized as those of hypertrophy and hyperplasia, together with those regressive disintegrating changes that must now be recognized as being characteristic of involution, (3) that the intervening parenchyma was normal in all respects, it would seem justifiable to conclude that these localized areas or nodules were the cause of the symptoms of hyperthyroidism in these cases. To this must be added the fact that when these areas or nodules were shelled out or removed by resection of the lobes of the gland the clinical state of hyperthyroidism disappeared. The histologic alterations associated with the hypertrophy, hyperplasia and involution or in other words, with the disease cycle of hyperthyroidism demonstrated to occur throughout the thyroid as a whole in exophthalmic goiter were thus found to be present even when the disease process was confined to one or more sharply localized areas of the gland while the normal structure of the hyperplastic thyroid parenchyma was maintained, and there was no evidence of the formation of new tissue or the histologic structure of the thyroid gland. Both of these facts speak against the likelihood of these areas being of a purely focal nature whereas the histologic appearance would suggest that the isolated regions or lobules or hyperfunctioning parts of the gland during the disease cycle hypertrophy and hyperplasia, and that the disease occurred many times.

## COMMENT

In a recent review of all the cases of hyperthyroidism in the Johns Hopkins Hospital, of which there were 710, together with 200 cases from three other hospitals in Baltimore, The Church Home and Infirmary, The Union Memorial Hospital and The Woman's Hospital, hypertrophy and hyperplasia of the parenchyma of the thyroid gland were demonstrated in every case. Hence, it can be stated definitely that, so far as our experience goes, the clinical syndrome, hyperthyroidism, has always been associated with hypertrophy and hyperplasia of the parenchyma of the thyroid. Moreover, it was thought that the microscopic appearance of the glands in these cases corresponded, as a rule, to the degree of hyperthyroidism—the more severe the clinical syndrome, the greater was the amount and extent of the hypertrophy and hyperplasia and vice versa. In 100 of these cases in which the clinical course had been acute and fulminating and in which neither artificial nor spontaneous remissions had occurred, there were found on microscopic examination a diffuse hypertrophy and hyperplasia of the thyroid, but no evidence of involutional changes. In seven cases in which the thyroid was examined before, during and following an artificial remission associated with iodine treatment, it was demonstrated that involutional changes occurred diffusely throughout the gland as a whole, but that in certain regions these had exceeded the average amount and had progressed to the formation of microscopic and even clinically palpable nodules which presented the histologic evidence of regression and even of disintegration. These areas or nodules were termed involutional bodies or areas of hyperinvolution and occurred in 200 cases of exophthalmic goiter in which the patients had undergone artificial remissions as a result of treatment with iodine. In fifty cases of severe hyperthyroidism—typical exophthalmic goiter—in which several spontaneous remissions had occurred, the thyroid was nodular and irregular in shape, and the patients gave the history of the nodules appearing in the gland during a remission following one of the exacerbations. On histologic examination, these nodules were composed of tissue similar in all respects to the involutional bodies or areas of histologic regression noted as developing during an artificial remission caused by iodine, and were involved in the present exacerbation just as was the remainder of the parenchyma of the gland as a whole. It is, therefore, possible for hyperthyroidism associated with a smooth diffuse hypertrophy and hyperplasia of the thyroid to give rise to a nodular gland or goiter as a result of artificial or spontaneous remissions with an associated involution of the gland. Thus, in cases of nodular goiter associated with hyperthyroidism in which the nodules showed the exact microscopic structure and appearance of these involutional bodies and in which the characteristic histologic changes—hypertrophy and hyper-

tissue immediately appeared normal (fig 10) Microscopic sections from the affected lung showed the histologic picture of complete atelectasis (figs 11, 12, 13, 14 and 15) Careful search of even the smallest bronchi did not reveal evidence of obstruction or of abnormal accumulation of secretion The alveolar walls were completely collapsed, and cellular infiltration could not be demonstrated (fig 15)

#### COMMENT

In the foregoing case, the massive atelectasis (collapse) of the lung was not due to bronchial obstruction It is interesting to note that section of the extrinsic nerves to that lung did not prevent the occur-

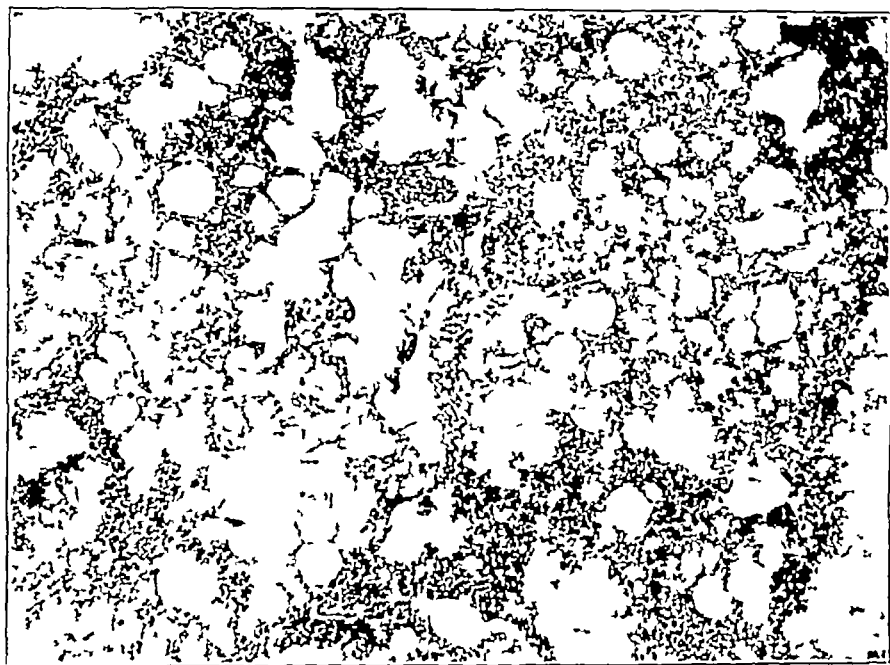


Fig 10—Section from the upper lobe of the collapsed left lung after it had been remsufflated,  $\times 100$

rence of the massive atelectasis (collapse) If there was any reflex responsible for this collapse, the impulses must have come by way of the anastomotic branches from the opposite side, or they must have originated in the peripheral ganglions of the affected lung It would be interesting to know if after a bilateral section of the extrinsic nerves to the lungs, massive atelectasis (collapse) of either lung could occur So far we have not been able to produce massive atelectasis (collapse) at will, therefore, further studies along this line cannot be made at this time

In our series we were unable to show any constant change in the frequency or character of the respiratory movements Papillian and

Our knowledge of the exact causation, development and character of the lesion known as osteochondritis dissecans is not exact, nor fully explanatory. Since Koenig's original observation, little of importance has been added

#### GROSS DESCRIPTION

The articular surfaces of the joint, as a whole, are normal, except for the loose fragment of the internal condyle and slight, irregular linear depressions of the cartilage of the external condyle, which are exaggerated in appearance in the photographs (figs 3 and 4). There is no lifting of the articular cartilage of tibia, femur and patella, nor any pannus formation



Fig 3—A gross specimen from a case of osteochondritis dissecans, the loose body is resting in its bed

The loose fragment is attached on its external border to the posterior crucial ligament by a thin band of fibrous tissue. The articular surface of the fragment is roughly a rectangle with rounded corners, 2 cm in width (internal to the external edge) and 2.5 cm in length (antero-posterior or sagittal plane). The fragment has a maximum thickness of 8 mm, including the articular cartilage which is from 3 to 4 mm thick. A prominent feature of the fragment is a transverse depression, shown clearly in figure 2, which divides it into two halves of about equal size. Beneath the cartilage, the fragment when sawn through shows the subchondral bone separated into two parts by loosely textured fibrous tissue. This is shown clearly in the photomicrograph which is

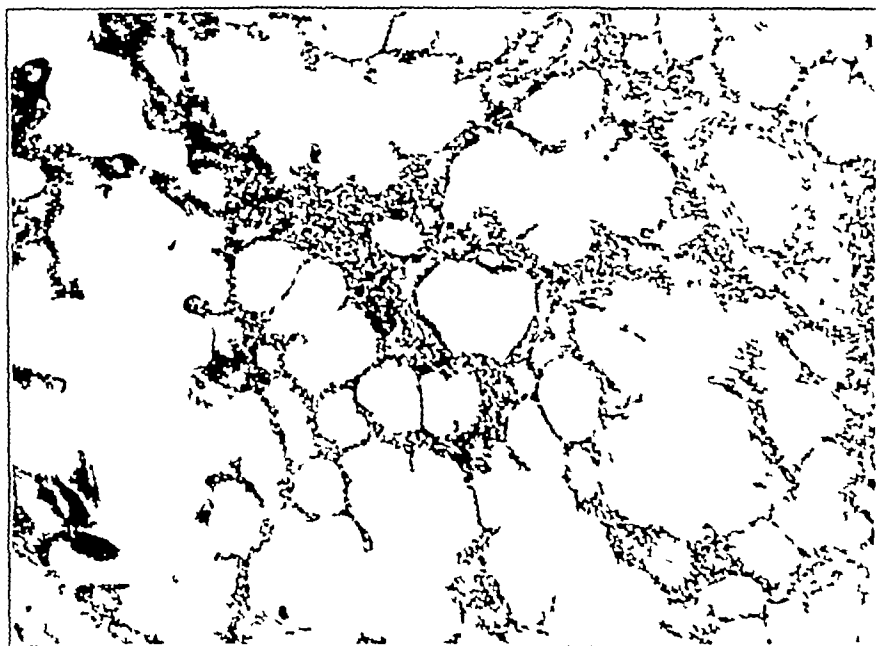


Fig 11—Section from the apex of the left lung of another dog, taken during the operation for partial denervation of that lung. Subsequently this dog developed massive atelectasis (collapse) of this lung. Compare with figure 12,  $\times 100$ .

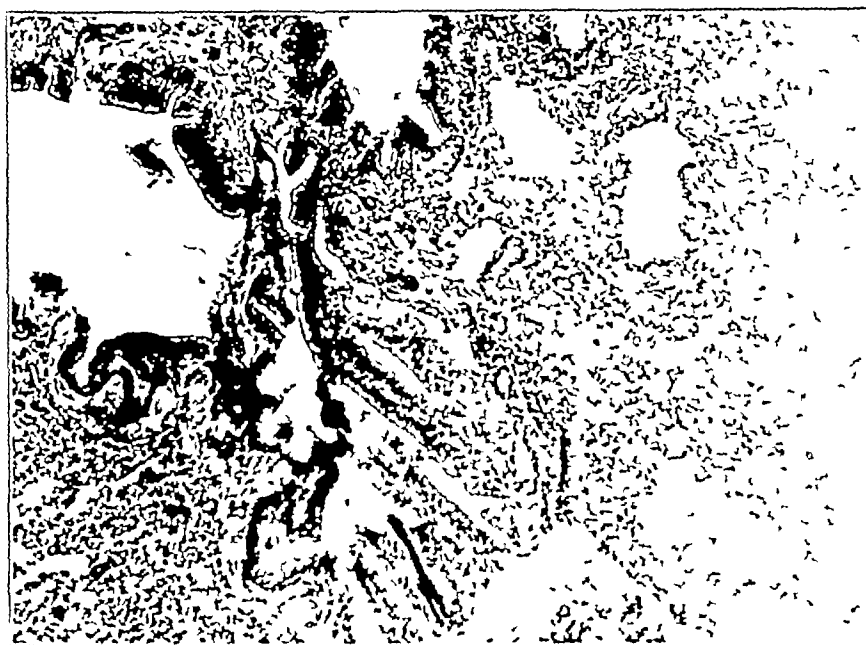


Fig 12—Photomicrograph of a section removed at autopsy from the right lower lobe after collapse of the lungs had occurred. Note the collapsed alveoli adjacent to a patent bronchus. This section is from the same animal from which the biopsy shown in figure 11 was taken three days previously.  $\times 100$ .

almost a replica of a figure in an article by Axhausen.<sup>1</sup> One cannot escape the conclusion that this buckling was purely a mechanical effect permitted by the character of the tissues deep to the fragment.

On the internal and the external margins, there is a granular cartilage deposit extending for a distance of from 1 to 4 mm on the deep surface of the fragment, continuous with the articular cartilage of the superficial surface. The reparative growth is not present on the anterior and posterior borders of the fragment.

The depression in the femur is smooth and lined with a thin layer of fibrous material. From both lateral margins there is a thin layer of cartilage extending from the surface downward for a distance of



Fig. 4—Same as in figure 3—The loose body is lifted from its bed, and the fibrous attachment to the margins of the internal condyle is shown.

from 3 to 5 mm. On the surface of the condyle at the internal margin of the depression, the articular cartilage shows some fragmentation and separation from the contiguous articular cartilages.

In order to obtain material for microscopic study, a saw cut was made through the internal condyle, passing through the center of the fragment and its socket roughly in the sagittal plane, but at a sufficient angle to avoid continuing the cut into the shaft of the femur. The plane of the section made an angle of 20 degrees with the axis of the shaft of the femur. This cut revealed an irregular cyst filled with soft-textured fibrous tissue lying immediately beneath the articular

Cruceanu,<sup>20</sup> however, stated that after section of the sympathetic trunk on one side, the respiratory rate is diminished for a period of about ten days following the operation. The explanation for this change is still lacking, but, whatever the cause may be, there is no doubt that the animal overcomes the effect. Within a few weeks after the operation, change cannot be detected, and the partially denervated lung reacts as its normal mate to all forms of physiologic and pathologic stimulation.

The heart and the intestine likewise cannot be denervated by section of their extrinsic nerves. Leriche and Fontaine<sup>21</sup> have shown that even the blood vessels have their own intrinsic nervous system. Our studies tend to show that the same condition exists in the lungs, and we are



Fig 13—Section from the upper lobe of the left lung of the same animal. There is also a patent bronchus surrounded by completely collapsed alveoli,  $\times 100$ .

convinced that the intrinsic nervous system of the lungs is able to function independently of the central connections. It is highly probable that all organs of the human body likewise have their intrinsic nervous systems and, under the proper conditions, could be made to function even after they had been separated from their central connections.

20 Papillian, V., and Cruceanu, H. Der Einfluss den beiders Cerv Sympath auf die Respirationsbewegungen, *Clujul Med* 4 1, 1923.

21 Leriche, R., and Fontaine, R. Faits chirurgicaux pour servir a la critique des theories actuelles de la vasomotricite. *Presse med* 31 481 1927. Recherches experimentales sur l'innervation vasomotrice, le reflexes vasculaires des membres, *ibid.* 51 852 1927.



depression. In fact, it was separated from it only by 2 or 3 mm of cancellous bone. It measured roughly 1.5 by 2.5 cm, and was irregular in outline. At a plane slightly external to this, as revealed in the sectioning of the slab removed for histologic purposes, there was another small cyst which shows well in figure 5.

#### MICROSCOPIC DESCRIPTION

The crater was lined with a thin layer of poorly-staining, refractive fibrillary material, containing few cells. Its structure indicated that it was probably atypical connective tissue. There was complete absence

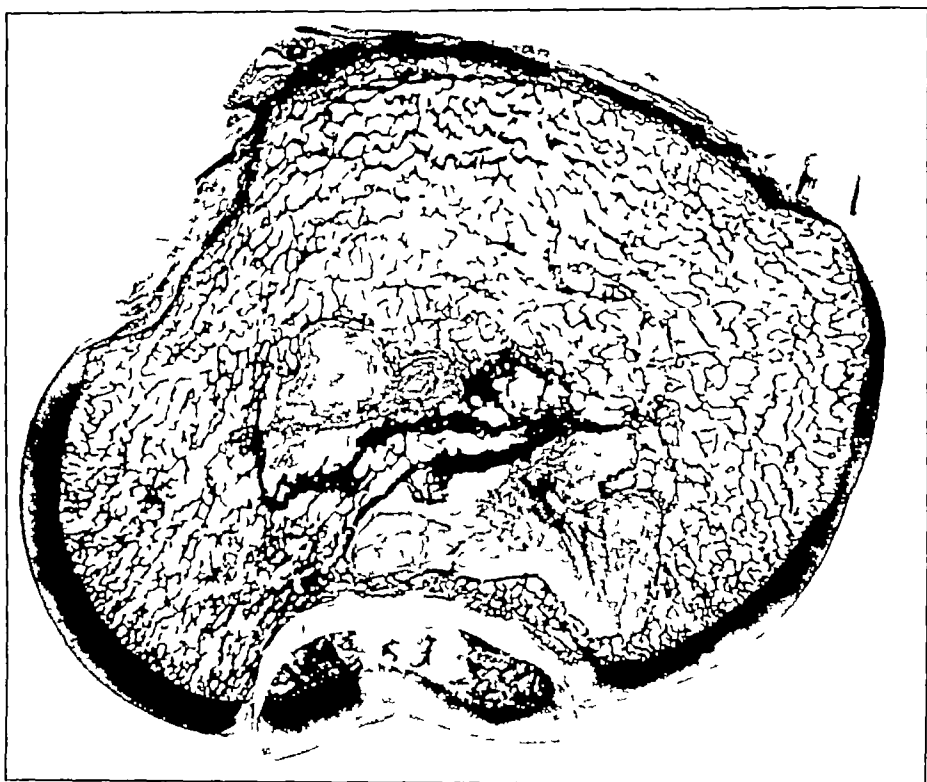


Fig 5—Osteochondritis dissecans, low power photomicrograph of a section removed from the specimen which cut through the loose body and the femoral condyle. In this section, the cysts in the condyle lying below the level of the loose body crater are clearly shown. The buckling of the articular cartilage on the surface of the loose body is evident. Reduced from a magnification of  $\times 19$  diameters.

of bone repair such as would accompany a fracture or an experimental incision of the bone in animals. The bone trabeculae of the crater wall, where they were in contact with the lining membrane, were thin and irregular, having the appearance of being excavated on their superior surfaces. There was a zone of deeply basic granular material between the bone and lining membrane, and the impression was that the bone matrix had undergone

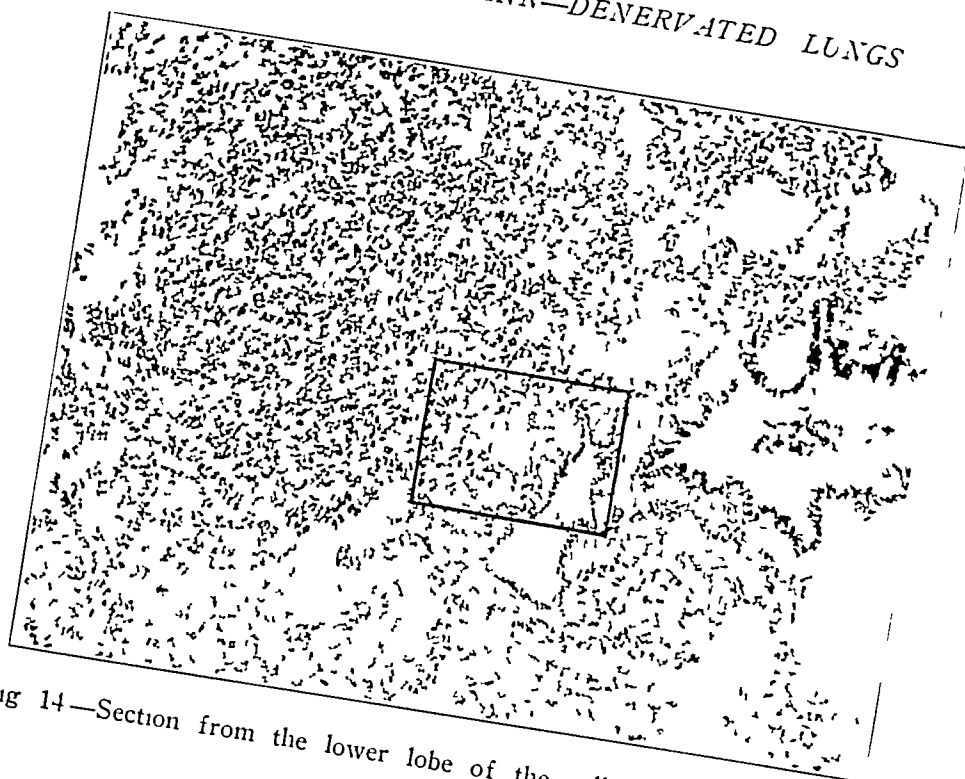


Fig 14—Section from the lower lobe of the collapsed left lung,  $\times 100$

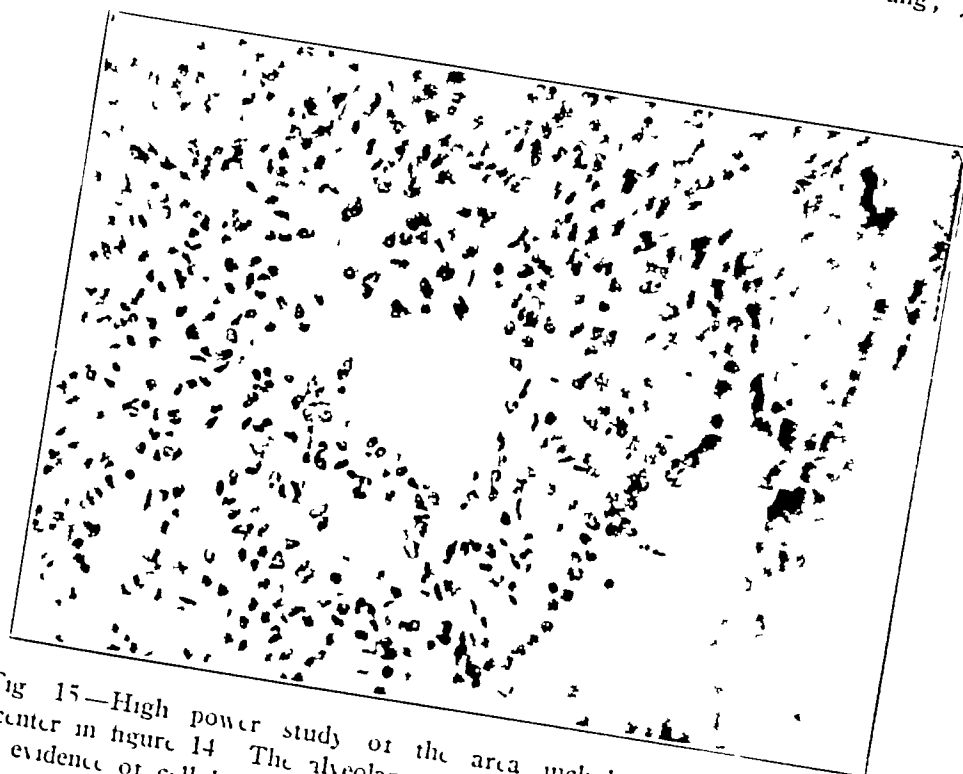


Fig 15—High power study of the area included in the square near the center in figure 14. The alveolar walls are completely collapsed and there is no evidence of cellular infiltration  $\times 430$

autolysis and released its mineral content. Cartilage cells were present here and there throughout in the crater wall close to the bone. Near the periphery or rim of the crater, they formed a thin, definite layer of cartilage with columns of cartilage cells and continuous with the articular cartilage. Thus the impression was forced on us that we were dealing with an unfamiliar reparative process without blood vessel formation, in which cartilage cells apparently originated from bone corpuscles released from the underlying trabeculae.

The cartilage of the fragment appeared to be viable. The cells were normal in appearance. The matrix stained less densely than normally, and this fact, together with the increased thickness of the layer of cartilage as a whole, is probably best interpreted as due to imbibition of liquid. The cancellous bone of the fragment was wholly dead. The interstices were filled with basic staining, granular detritus. The bone trabeculae were deeply stained with eosin, and were refractive and without stainable cells. Giant cells or other viable cells were not present.

The "cysts" may be described as regions devoid of bone trabeculae and without specialized boundary zones. The bulk of tissue in these regions was a loose-textured, myxomatous-like connective tissue enclosing small numbers of fat cells. In places, there were dense fibrous tissue bands traversing these regions. At the peripheries there were compact fibrous tissue or merely the normal fat laden cells of the marrow. In many regions, fat cells were separated by faintly staining material containing delicate fibrin strands, migrating polymorphonuclear leukocytes and mononuclear cells—acute changes explained by the presence of blood vessels filled with chains of streptococci, the evidence of a terminal septicemia.

Blood vessels were numerous in these "cysts," except in central regions in which the tissue was compact. Here there were few blood vessels and large extents of tissue had none. Small circular, outlined cavities were found in such regions, the result of necrosis and liquefaction, as shown by the fact that the immediately adjacent fat and loose-textured fibrous tissues were without nuclei and presented other evidences of death. In many places throughout the "cysts" the impression was obtained that the fat cells had undergone necrosis, without decomposition of the fat, and that the myxomatous appearance of the intervening connective tissue was a consequence thereof, and to be interpreted as edema with avascular organization.

Important lesions of arteries and veins were absent throughout the extent of the cancellous bone.

As is obvious from the foregoing account the histologic observations have not yielded any clue to the processes antecedent to the separation of the fragments. Neither is there any explanation of the origin of the cysts.

Our experiments tend to throw some light on the explanation for the numerous failures which follow operations on the sympathetic or parasympathetic systems in the surgical treatment of bronchial asthma. We exclude, of course, the failures due to improper diagnosis and improperly performed operations, since these causes for failure have been considered in detail by Leriche and Fontaine<sup>22</sup>. The failures of relief after such operations are still numerous, even in typical cases of asthma in which no special sensitization for foreign matter can be demonstrated. This must be explained on the basis that the reflex paths to the lungs are not completely interrupted. Theoretically, in order to do this it would be necessary to sever both vagi, to remove both stellate ganglions and to cut the upper four thoracic rami communicantes on both sides. Practically, however, this is impossible in man, since one vagus nerve must always remain intact.

Kummel<sup>23</sup> first proposed the resection of the cervicothoracic sympathetic trunk for relief from bronchial asthma. Subsequently, he modified this procedure by using the intrathoracic approach and severing part of the branches of the pulmonary plexuses<sup>24</sup>.

Our studies have shown that such a procedure is no better than the simple removal of the stellate ganglion. When we consider that the intrathoracic approach is much more dangerous than the cervical approach, we cannot believe that Kummel's second procedure has any advantages over his original one. If, in spite of the added risk, one prefers the intrathoracic route, the operation should consist in the removal of the upper part of the thoracic sympathetic trunk, complete extirpation of the stellate ganglion and, finally, section of the vagus nerve on the same side. We believe, however, that a small number of failures will probably always occur after any of the foregoing procedures in fact even after complete bilateral resection of the extrinsic nerves to the lungs, if that operation could be performed with safety, because of the persistence of the peripheral ganglions situated in the walls of the bronchi. These ganglions probably play an important part in the production of bronchial asthma.

#### CONCLUSIONS

1. In the dog, partial denervation of one lung is a safe surgical procedure and can be accomplished by unilateral resection of the first four thoracic sympathetic ganglions, the removal of the ansa Vieusseni

22 Leriche, R., and Fontaine, R. Sur le traitement chirurgical de l'asthme bronchique, *Bull et mem Soc nat de Chir de Paris* **52** 748, 1926.

23 Kummel, Herman, Sr. Ursache der Misserfolge bei operativer Behandlung des Bronchialasthmas und ihre Beseitigung, *Arch f klin Chir* **142** 499, 1926.

24 Kummel, Herman, Sr. Der heutige Stand der chirurgischen Behandlung des Asthma bronchiale, *Therap d Gegenw* **68** 15 1927.

A return to the study of gross relationships of fragment and cavity encounters two facts for consideration the buckling of the fragment also clearly illustrated by Axhausen, and the discrepancy in size of the fragment and the capacity of the cavity. The buckling of the fragment naturally suggests the effects of the yielding of a surface inadequately supported from below. The presence of the "cysts" or areas devoid of bone trabeculae beneath the cartilage naturally suggests the existence of the requisite mechanical factors before the event. Inspection of the curvature of the articular cartilage in the plane of sections utilized for figure 5 seemed to indicate too great a convexity of the surfaces on each side of the cavity. Therefore, a normal femur was obtained, sectioned in the same place, and superimposed, with the

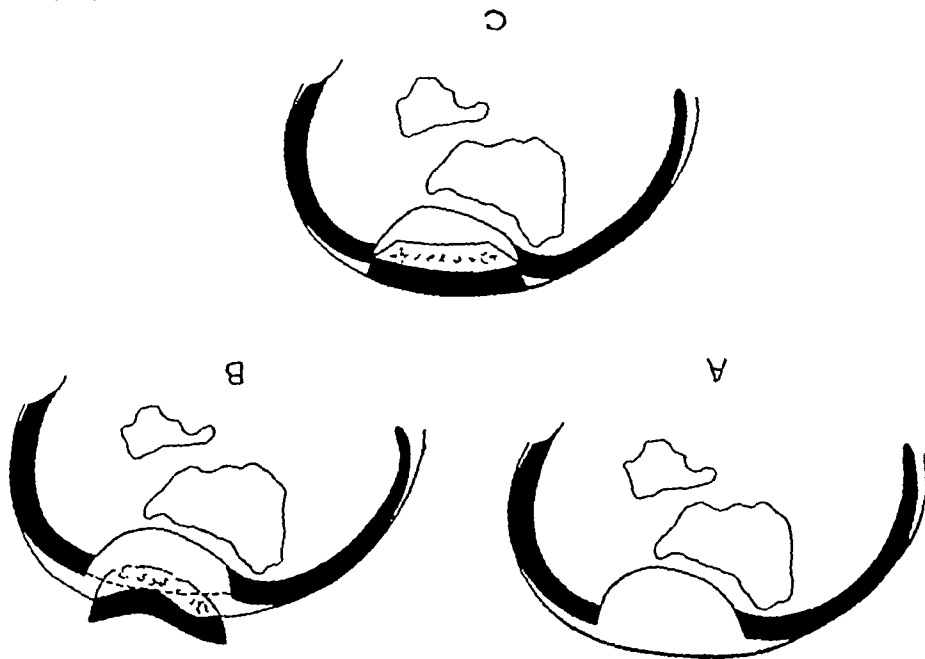


Fig 6—Osteochondritis dissecans, comparison of the specimen with the outlines of a normal femur which are superimposed. The probable thickness and curvature of the articular cartilage prior to separation of the loose body is shown in B. In C, the fragment or loose body is represented as restored to its original contour, revealing an unfilled space which existed before the separation of the fragment

result shown in the diagram of figure 6A. Restorations of the probable thickness and curvature of the articular cartilage prior to the separation is shown in figure 6B, the inferior dotted line representing the deep surface of the articular cartilage. In this diagram, the buckled fragment is placed in position with the deep surface of the cartilage coinciding with the reconstructed line of the original deep surface. In figure 6C, the fragment is represented as roughly restored to its original contour, revealing a considerable unfilled space and forcing the conclusion that a "cyst" existed in this situation before the separation of

and the stellate ganglion together with the resection of that portion of the vagosympathetic trunk which has included in it the middle cervical ganglion

2 Section of the extrinsic nerves that lead to one lung does not cause any change in the frequency or character of the respiratory movements

3 The partially denervated lung reacts as its normal mate to all forms of stimulation

4 The carbon dioxide combining power of the blood plasma remains unchanged after partial denervation of one lung

5 Section of the extrinsic nerves that lead to one lung does not prevent the occurrence of a typical massive atelectasis (collapse) of that lung

6 The ganglions situated in the bronchial walls remain intact after the most extensive operation that is directed to produce complete denervation of one lung, consequently, it is technically impossible to obtain a complete denervation of either lung

7 Because of the persistence of the peripheral ganglions, there will probably always be a few failures from the surgical treatment for bronchial asthma, regardless of which operative procedure has been carried out

The reason for the buckling of the bone and cartilage comprising the fragment is thus accounted for. The change in the curvature of the articular surface of the condyle may also be explained on the basis of the yielding of the bone deprived of support by the absence of a considerable volume of cancellous structure as represented by the several cysts.

The buckling of the fragment probably was the first important mechanical consequence of the change in shape of the cartilage yielding under pressure, and suggests the consequences of lateral stress, a warrantable inference is that the cyst into which the fragment collapsed was originally considerably greater in its lateral (horizontal, anteroposterior) dimensions.

Another inference drawn because of the absence of recognizable new bone formation in the crater is that along the line of separation of the fragment this cyst extended close to the deep surface of the articular cartilage.

On the basis of the microscopic and gross study of the sections, we venture to offer the following explanation of the specimen of osteochondritis dissecans which came into our hands.

The separation was the effect of mechanical pressure on a portion of the articular cartilage with underlying cancellous bone bridging a "cyst." This pressure probably was intermittent, as occasioned by variation in functional performances of the joint, and probably was the resultant of stresses operating roughly in the long axis of the bone and laterally in the anterior-posterior direction. The lateral stresses are suggested by the change in convexity of the articular surface and the presence of large defects in cancellous bone deep to the lesion. The effects of the loss of the cancellous bone in volume represented by the cysts we think are shown by the shortening of the anteroposterior diameter of the condyle, as shown in figures G, I, H, and C, and by the buckling of the fragment.

There are two essentials to our explanation—one, a sufficient loss in the condyle of cancellous bone to weaken materially the support of the articular cartilage as a whole; the other, the presence of a "cyst" immediately below the articular cartilage in a position subject to vertical and horizontal stresses.

The rarity of typical instances of osteochondritis dissecans of the femur suggests that our explanation, even if dependent on the fortuitous existence and distribution of cysts," may apply to other examples.

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# OSTEOCHONDRITIS DISSECANS \*

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AND  
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The present study was made on a specimen removed at autopsy. The patient was reported to have died of diabetes mellitus. During the progress of the autopsy, the knee was discovered to be slightly swollen. Clinical symptoms of trouble with the knee were not recorded, but when the knee was opened, a typical instance of osteochondritis dissecans was found.

The discovery of loose bodies within a joint, especially the knee, has been of great clinical interest, both in respect to the origin of these bodies and as regards treatment. Various names have been used to describe them, such as "joint mouse," "loose body," "floating body" and others. There are several varieties, namely, those which result from a disease process, such as tuberculosis, tabes or pus infection, those which follow definite trauma, wherein a portion of bone and cartilage is broken off, those which result from proliferative changes in the cartilage or synovial membrane as a result of arthritis, and lastly, those in which the origin is obscure or only partially explainable.

It is the latter class which concerns us in this study.

## CLINICAL COURSE

In certain instances with or without recognized trauma, patients develop a symptom complex which suggests that there is a loose body in one of the joints. By far the most frequently affected joint is the knee. The symptoms complained of are usually slight swelling, slight discomfort and at times, locking of the joint. Roentgenographic study will at times reveal the loose body, either free in the joint or attached to the articular surface (figs 1 and 2). Operative removal is indicated. At operation, the loose body is picked out of the articulation. It may be freely movable in the joint cavity, or it may still be resting in its bed. Examination of the body will show a surface of articular cartilage, oval or rounded, with clearcut edge, and an under surface of the subcartilaginous cancellous bone. This body will exactly fit into a defect in the surface of the articular cartilage, the craterlike defect

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\* From the Harvard Medical School



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will also have a clearcut edge of cartilage, with a base more or less filled with fibrous tissue, depending on the period of time which has elapsed since the body fell out of its bed

This type of loose body in a joint is that which Koenig has described as "osteochondritis dissecans" It occurs most frequently in the internal condyle of the femur, but it also has occurred in the elbow, the hip

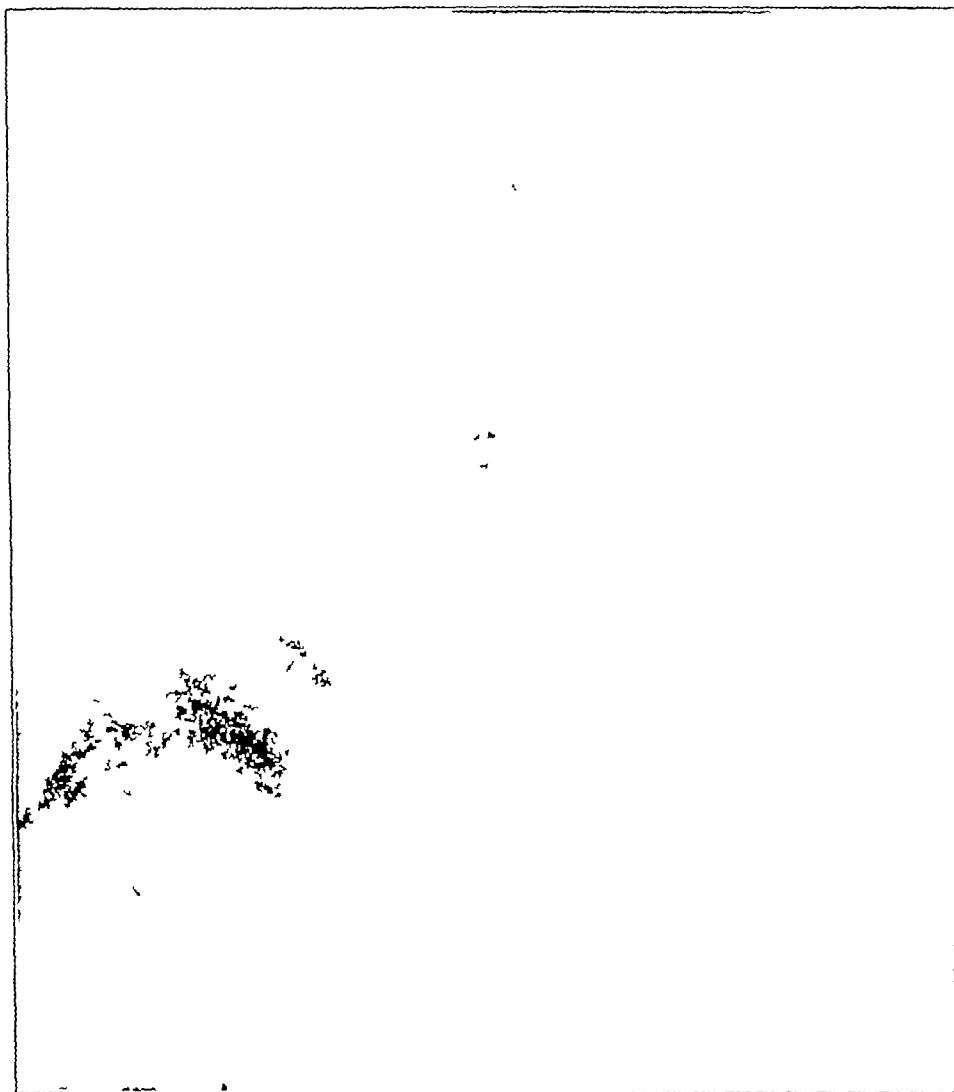


Fig 1—Osteochondritis dissecans. The loose body is clearly shown in the lateral plane

and the shoulder joints. It is to be remembered that these joints do not present any other evidence of disease process, nor are there constitutional disturbances present, such as elevation of temperature or illness, locally, signs of inflammatory process, such as heat and redness, are not seen, the pain and swelling present being due to joint irritation of a mechanical nature



## OBSERVATIONS ON THE CAUSATION OF LOOSE BODIES IN JOINTS

About 250 years ago Pechlin studied and, in a way, described the various types of loose bodies in joints. In 1726, Monroe advanced the theory that trauma plays an important rôle in the formation of loose bodies. In 1848, Raney observed that fragments of cartilage

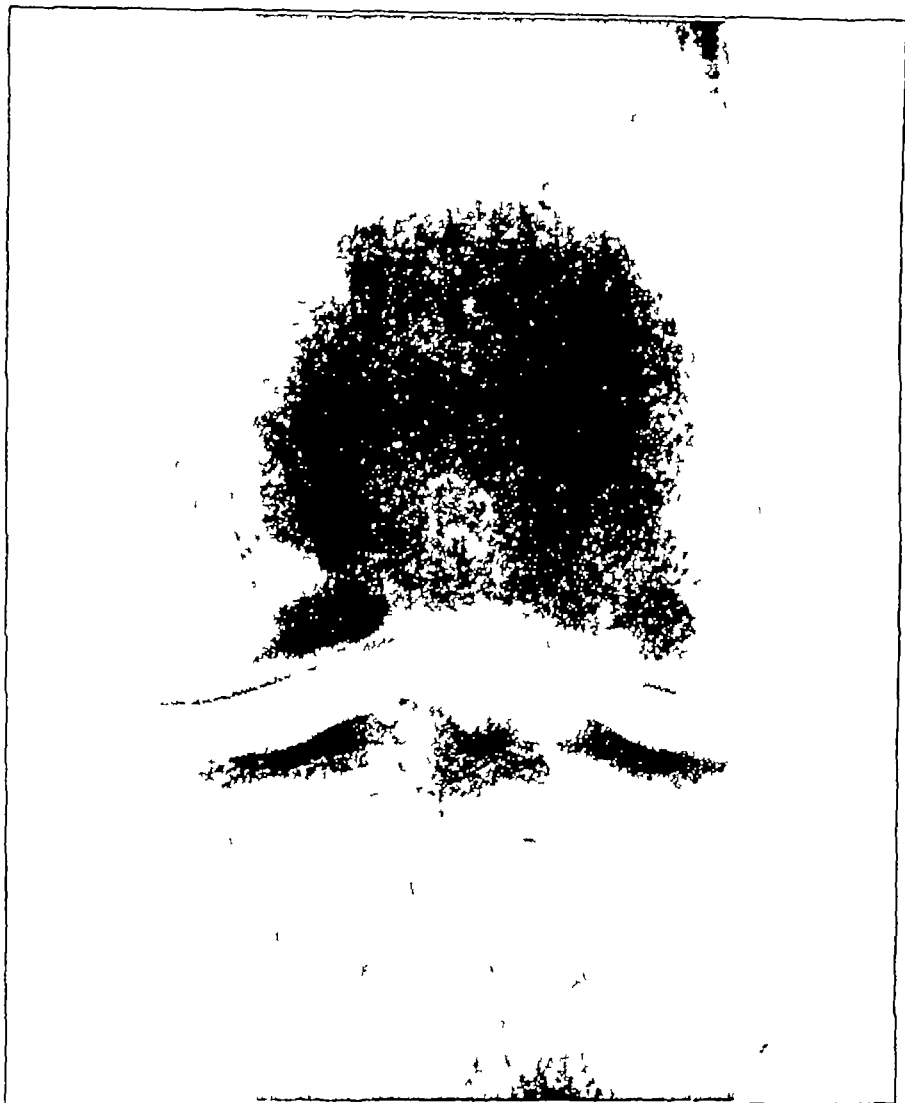


Fig 2—Same as figure 1, taken in the anteroposterior plane. The loose body at the surface of the internal condyle is less clearly indicated.

and bone detached within the joint by trauma continued to grow and become sizable loose bodies, regardless of their parent structure. In 1851, Rokitsansky stated his belief that bodies composed of bone and cartilage might arise from the articular serosa, representing an excessive development and ossification of isolated nodules of cartilage. John Hunter believed that loose bodies within a joint were at first blood

and mucoid tissue in the thyroid tumors does not appear to be a degenerative process, but a part of the life history of the tumor. The term "mixed tumor" is properly applied to those ovoid growths which are found within the normal or goitrous thyroid gland, the structure of which resembles that of the underdeveloped gland. Its chief gross characteristics are the uniform ovoid shape, the division into reniculi-like pyramids, often with central areas of fibrous tissue, and its definite encapsulation.

Closer acquaintance with this tumor is desirable, because it has a life history of its own, and because it has been constantly and persistently confused with the nodules commonly found in lobulated colloid goiters. This confusion has been so complete that many writers believe that the nodulations of the old colloid goiters go through a stage simulating or identical with that of the so-called fetal adenomas. The delusion is at once apparent when the structure of small mixed tumors are compared with the interacinar new formation of glands.

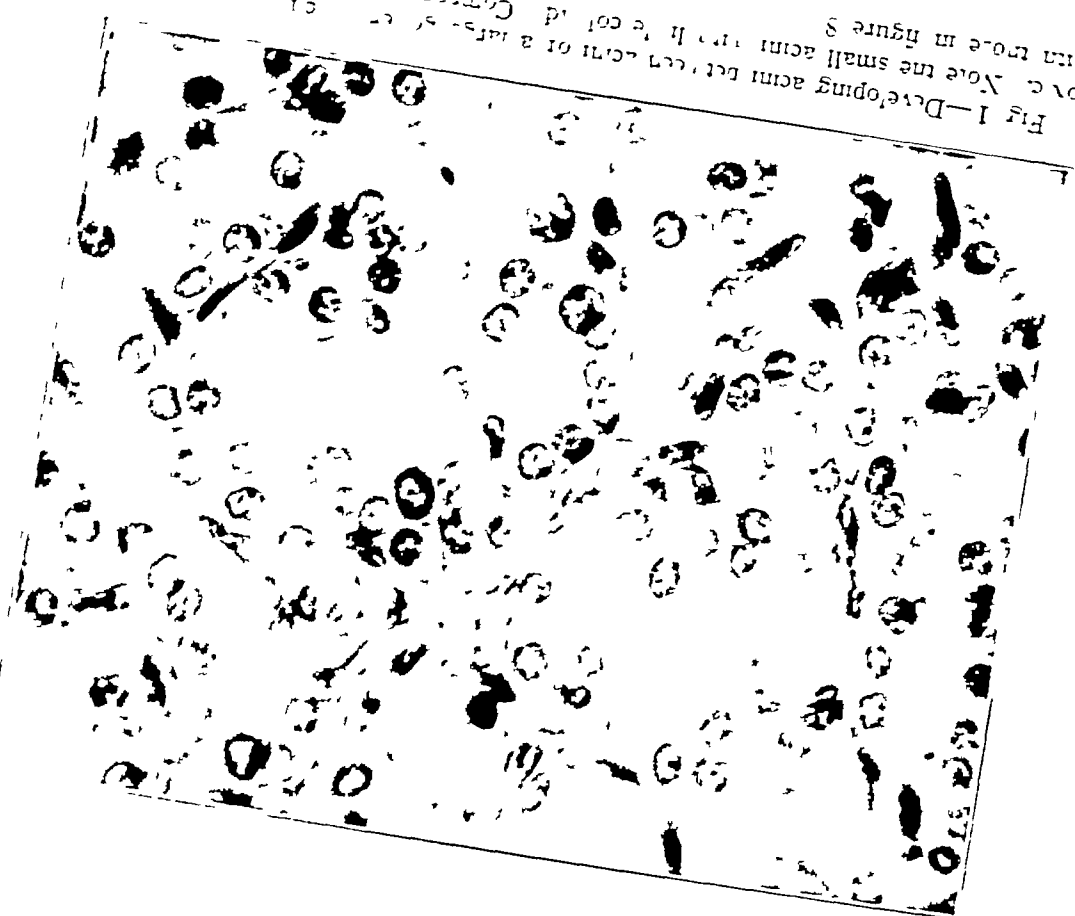
The actual source of these tumors is not known. Clinically they are commonly seen in young persons, when they are no larger than a hazelnut. Wolff<sup>1</sup> assumed that they are derived from certain groups of cells of fetal origin situated in the interstices between the acini of the tumors. In rare instances, one finds small islands in the interior of goiters of glands typical of these tumors, but whether or not the beginnings of the tumors are in such islands is not known. Most authors who have published illustrations of these alleged islands have presented only high magnifications of a few glands, making it impossible to judge of the topography of the environment. Any one with a willing disposition and a high power lens can prove almost anything particularly if it is "von Verfasser gezeichnet." As a matter of fact, such groups of cells (fig 1) are frequently found in glands that show a beginning toxicity. But they are multitudinous (fig 2), and one would have to assume that each of these areas may be the point at which the future adenoma will develop. True enough, areas identical with the fetal adenoma are found in goiters now and then (fig 3). I have encountered such islands in less than one half of 1 per cent of goiters. Furthermore, most of these little islands showed evidence of degeneration, indicating that they have failed in development and are not potential tumors of magnitude. Those who assume that each of these "adenomas" is derived from such an area, hypothesize something unusual in ontogenesis. The multiple origin of true tumors should not be hypothesized without the backing of definite evidence, a thing wholly lacking in this connection.

clots which became organized and attached to articular cartilage, and which assumed its characteristics. Laennec's (1854) theory was that following an arthritis, cartilage might develop in the thickness of the fibrous capsule or in the synovial tissue, and that it might develop the structure of articular cartilage. Paget believed that loose bodies were sequestrums which followed a "quiet necrosis" localized in the base of the articular cartilage. He believed that trauma did not play any part in causation. Journeaux and Hermann (1889) produced evidence of the synovial origin of certain types of loose body, and they believed that synovial cells might take on the characteristics of cartilage cells. Poulet and Villard, at about the same time, expressed the belief that loose bodies in joints were always due to a condition known as "dry arthritis." In 1887, Koenig wrote his description of a distinct pathologic entity which he called "osteochondritis dissecans." He believed that this was an inflammatory lesion of unknown origin, which resulted in the occlusion of the terminal arteries supplying an area of the articular cartilage on the mesial condyle of the femur, producing a separation of a small area of cartilage, and that this area dropped out of the surface of the cartilage with a shell of subchondral bone attached, thus becoming a loose body in the joint space. Koenig realized that trauma might act as a causative factor. His description and explanation aroused considerable controversy. Lever (1910) advanced the view that certain loose bodies might arise from "embryonic rests" of cartilage cells. Freiburg (1910) reported several well studied cases, and stated his belief that Wollenberg's vascular theory offered a full explanation of the origin of loose bodies. Anhausen (1924) confirmed Koenig's observations as to origin, and drew a forcible comparison between the loose bodies in the knee, in the elbow and in the hip and the osteochondritis known as Legg-Perthes's disease, Kohler's disease of the metatarsal head and tarsal scaphoid. He believes that a slow absorption and necrosis start in the epiphysis and develop into a line of demarcation composed of granulation tissue which is replaced by fibrous tissue. An intercurrent injury jars the loose piece of cartilage loose from its bed. The primary cause is either trauma to smaller blood vessels of the epiphysis or a benign type of emboli lodging in the terminal vessels of the epiphysis.

Timbrell Fisher (1924) showed by experiments on animals that trauma to the epiphysis will produce a low grade type of inflammatory process in a certain area, which thus has lowered vitality and which may be gradually extoliated. Many observers, notably Codman, have experimented in the production of the actual lesion of osteochondritis dissecans by striking the femoral condyle with a hammer. The lesion may be produced thus in the knee of a cadaver.



Fig 1—Developing acini with small acini and large acini. Note the small acini with the colloid. Cortical reaction of the acini with more in figure 3



plasia—had occurred during an exacerbation in sympathy with the remainder of the parenchyma, it would seem likely that the nodules were of similar origin. In this study, 34 per cent of the cases fell in this group. In a previous study, fifty such cases were reported. The histologic changes of hypertrophy and hyperplasia which occurred throughout the gland also involved the hypervoluted parenchyma forming the nodules and clinical tumors. This involvement did not occur in 8 per cent of the cases of true neoplasms.

In 1905, MacCallum<sup>2</sup> first called attention to the fact that in cases of exophthalmic goiter the histologic changes denoting hypertrophy and hyperplasia might be confined to "small patches here and there throughout a gland which otherwise seems normal. Microscopically, the altered areas are quite sharply demarcated from the rest and may involve a great number of alveoli or be limited to very small foci, including only a few alveoli here and there." The cases originally studied by MacCallum were included in the Johns Hopkins Hospital, and his original observations were confirmed, not only for the cases up to 1905, but also for those from 1905 to 1927. Hence it would appear certain that in hypertroidism, hypertrophy and hyperplasia of the parenchyma may occur only in certain regions and in certain lobules of acini, or it may involve the thyroid gland diffusely and as a whole. The only difference in the clinical manifestations of the cases associated with diffuse involvement of the gland and those in which only certain well defined areas were affected by the morbid process was that the latter group as a rule was of a milder type. It has been pointed out that the most severe cases of hypertroidism, in which the entire thyroid gland is involved in the pathologic hypertrophy and hyperplasia of the parenchyma undergo artificial and spontaneous remissions associated with a histologic transformation that is characterized by involution, regression and actual disintegration of the parenchyma. Therefore, when the pathologic hypertrophy and hyperplasia are limited to certain specific areas of the gland it would be expected that the involutional changes associated with clinical remissions, whether artificial or spontaneous, would also be limited to these areas. This was true in 58 per cent of the 107 cases of the present study, in which there was a nodular goiter associated with a low grade clinical hypertroidism of long standing. In these cases the thyroid glands were examined at the height of an exacerbation. It was found that the nodular elements were composed of the same parenchyma in which the histologic changes associated with the morbid phase of the disease cycle, i.e. hypertrophy and hyperplasia, were



simultaneously with those alterations in the microscopic structure concomitant with involution of a previous hypertrophy and hyperplasia. The parenchyma intervening between these nodules had the appearance of normal thyroid tissue. Thus, it would seem that the disease, hyperthyroidism, pathologically may be divided into two phases: an active phase associated with the histologic changes denoting hypertrophy and hyperplasia, and an artificial or spontaneous, less active phase associated with involution of the hyperplastic parenchyma. The disease cycle and its associated morbid pathologic process may involve the entire thyroid or only portions of specific and well defined areas of the gland.

Formerly, only the pathologic changes in the thyroid (hypertrophy and hyperplasia) associated with the active stage of the disease were recognized mainly because the patients were either operated on at the height of an exacerbation or died during a fulminating stage of the disease. A check between the clinical severity and the histologic structure became possible with the advent of the determination of the basal metabolic rate and the reintroduction of the use of iodine in the treatment of patients with hyperthyroidism. Under these circumstances, it has become necessary to change one's ideas in regard to the histologic alterations encountered in the thyroid in cases of hyperthyroidism. Whereas, before, the presence of large cysts, encapsulated areas of dilated colloid-containing acini and diffuse scarring were little understood, their pathogenesis can in the light of the now known involutional changes, be rationally explained. For years all nodules or lumps in the thyroid have been termed "adenomas," because encapsulated sharply defined areas of hyperplastic thyroid parenchyma, associated with histologic regression or disintegration and fibrous tissue substitution differed in its pattern from the old ideas of the histologic structure of exophthalmic goiter.

When analyzed in the present state of our knowledge, the nodules in this group of sixty-three cases were found to be composed of thyroid parenchyma in an active state of hypertrophy and hyperplasia associated with the microscopic changes characteristic of involution. Depending entirely on the duration of the disease or on the number of times the disease cycle has been completed, the involutional changes, such as fibrosis, or central acinar disintegration with deposition of colloid and cyst formation, will be in evidence. Thus, in older people in whom the disease process has extended over a long period of time, the extent of histologic regression will be greater in these areas, the encapsulation more pronounced and the nodules larger. In some of these nodules only a small rim of thyroid tissue remains. In our series of controlled cases, the process of hypertrophy and hyperplasia was apparently attended with an enlargement of the whole thyroid, which was again increased during involution owing to the deposition of colloid. It

The development of the common uniform colloid goiter into the nodular type can be easily traced from the formation of new acini in the interstitial cells and from the walls of the old acini, as discussed in my previous paper

Ribbert declared that fetal adenomas are seldom seen in children. I find them commonly in small children, usually in the absence of enlargement of the gland proper. In the soft goiters of adolescents, they are often conspicuous as small firm nodules easily detected in the softer tissue of the goitrous gland. That they are something apart



Fig 3—Small "fetal adenoma" in an old colloid goiter only recently becoming toxic. The nodule, tiny as it is, shows degeneration indicating its age.

from the goiter proper is shown by the fact that they are not influenced by treatment. They never become smaller as the goiter as a whole approaches the normal.

These tumors are nearly always solitary and commonly exist as the only thyroid lesion. Their encapsulation causes them to be definitely separated from the surrounding tissues, causing them to be freely movable. Their capsules, however, are nearly always definitely suffused with the capsule of the thyroid gland. The gland about them is pushed to one side by the growth of the tumor. Because these tumors have been confused with the bossilations of old colloid goiters, this characteristic has been ascribed to all so-called "adenomas." It is only these

## CONCLUSIONS

- 1 Mixed tumors are true tumors of the thyroid gland
- 2 They are comprised of acini more or less characteristic of immature thyroid tissue
- 3 The fibrous tissue is prone to have a characteristic keloid-like proliferation and mucoid degeneration
- 4 The acini may develop colloid and later undergo the changes of an old colloid goiter, leading to toxicity. The toxicity never reaches the degree of a true exophthalmic goiter
- 5 The tumors may menace the life of the patient by a hemorrhage into their substance
- 6 They may undergo active acinar proliferation leading to malignancy

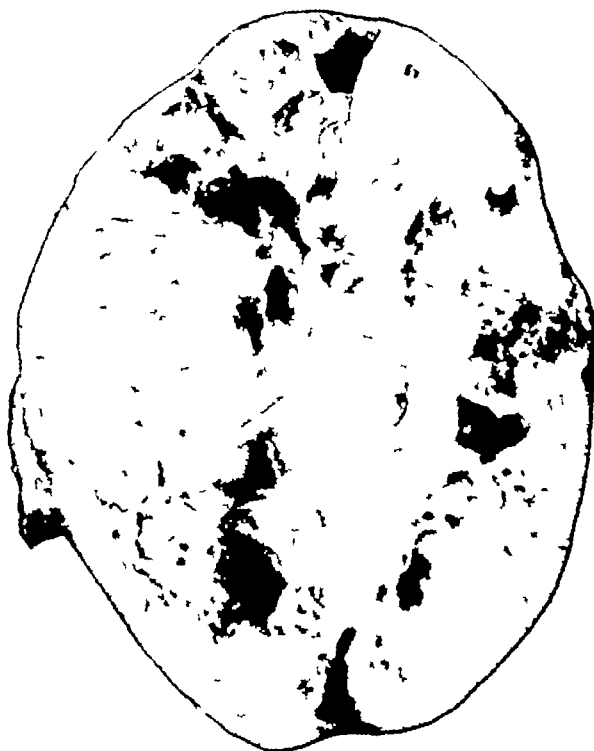


Fig. 4—Cross-section of a typical mixed tumor. The ovoid form, the central fibrous core and the indefinite division into lobules are well shown.



Fig. 5—The entire tumor and a cross-section of the same. The central core is cystic and there is an irregular cystic area to the left of the center.





Fig 6—Tumor with extensive central fibrous area with the rencula-like areas about the periphery



Fig 7—Large bossiated colloid goiter showing the innumerable small nodules In order to fit this into the "adenoma" theory it is necessary to hypothecate a separate focus of origin for each nodule

good and she was allowed to walk about. On August 2, while walking, she began to feel weak. The dressings became saturated with blood, and she died almost immediately.

*Autopsy Report*—The autopsy was performed the following day by Dr Paul Klemperer. The most important facts are given from the complete report. There was a healing thoracotomy wound in the right side of the back with resection of



Fig 1—The polypoid growth attached to the lateral wall and partly filling the lumen of the bronchus of the lower lobe. The probe is introduced into the tear of the aneurysmatic pulmonary artery branch within the wall of one of the bronchiectatic cavities distal to the neoplasm.

several ribs. In the base of the wound there appeared several lumina from which blood exuded on pressure. The right lung was firmly adherent to the wall of the chest and was removed with difficulty. The right lung weighed 550 Gm, the left, 310 Gm. On opening the lung (from behind), the bronchi of the upper and middle

mixed tumors that push the gland aside. The bossilations of the old colloid goiters are part of the once diffusely enlarged gland, and there is no normal gland to be pushed aside, or to be saved at operation, as every discerning surgeon knows.

More important than any theory as to origin is the structure of the tumor itself.

#### PATHOLOGIC ANATOMY

The most striking characteristic of the tumors is their constant ovoid shape, whether they exist alone or as a part of a nodular colloid goiter (fig. 4), less often they are spherical (fig. 5). They are never lobulated and they are nearly always solitary. They are firm to the feel and are generally elastic. When they have undergone degeneration, they may be soft or fluctuant.

On section, they are found to be deep red, unless they have undergone secondary degeneration. They are commonly divided into separate pyramidal lobules, the apexes of which point to a common center like the divisions of a grapefruit (fig. 4). In most of them, there is a white core, usually stellate. This core may form only a small nucleus in the center, or it may occupy the larger part of the tumor (fig. 6). This arrangement of the small lobulations with the white center is sufficient to differentiate them from the nodules of a colloid goiter (fig. 7). In many of the older ones various forms of degeneration are noted, this degeneration is usually cystic, but is often colloid and sometimes hemorrhagic. These tumors are always surrounded by a heavy connective tissue capsule, heavier than the true capsule of the normal thyroid gland.

#### HISTOLOGY

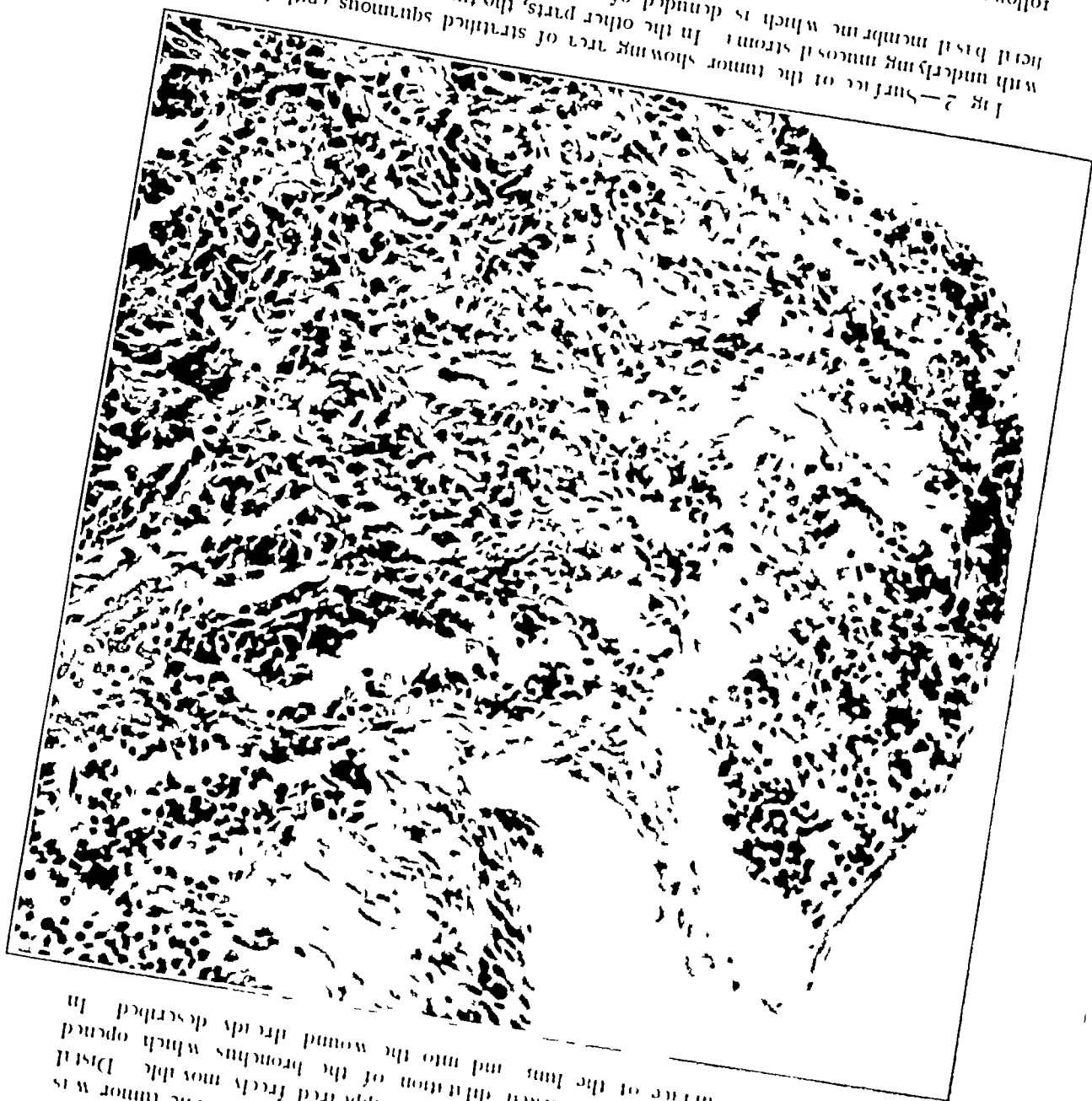
Figure 8 shows the tumor to be made up of closely packed acini. In the younger specimens, few or none contain colloid. The cells are small and closely packed; the nucleus is spheroidal and the protoplasm deeply staining. It is interesting to compare the structure of the salivary mixed tumors with such pictures (fig. 9). In the older ones, the colloid is small in amount, acidophilic and without vacuolization, even in specimens fixed in a solution of formaldehyde. As the tumors grow older the acini may all contain colloid and the slide may resemble closely the acini of the old colloid goiter (fig. 10).

The most striking and constant picture of these tumors is to be seen in the central stellate area already mentioned. These areas are always made up of heavy bundles of fibrous tissue, recurrently bedded, and contain few if any cells. They are found in colloid goiters and in old specimens, take the dye poorly or not at all. These areas seem to grow usually into the connective tissue between the nodules of the colloid goiter.



Following the various ramifications of this bronchus numerous sacculated bronchial dilations were found some of which were filled with blood. Within the wall of one of these bronchi the cavity there was a blood vessel which showed an irregular tear. A probe introduced into this tear appeared within a branch of the second order of the pulmonary artery. The ruptured portion of the

Fig 2—Surface of the tumor showing area of stratified squamous epithelium with underlying mucosa of stomach. In the other parts, the tumor reaches the superficial basal membrane which is denuded of epithelium, X 80



lobes of the right lung were found to be normal. Within the lumen of the main bronchus of the lower lobe of the right lung there appeared a cylindrical pedunculated tumor which measured 21 mm by 6 mm (Fig 1). The tumor was attached to the lateral wall of the bronchus and appeared freely movable. Distal from the tumor there was marked dilation of the bronchus which opened directly on the surface of the lung and into the wound already described. In



Fig 8—Slide from a mixed tumor of ten years' duration *A* indicates an area near the periphery showing the small acini some of which are beginning to accumulate colloid, *B*, an area nearer the center of the tumor showing the developing mucoid tissue between the acini

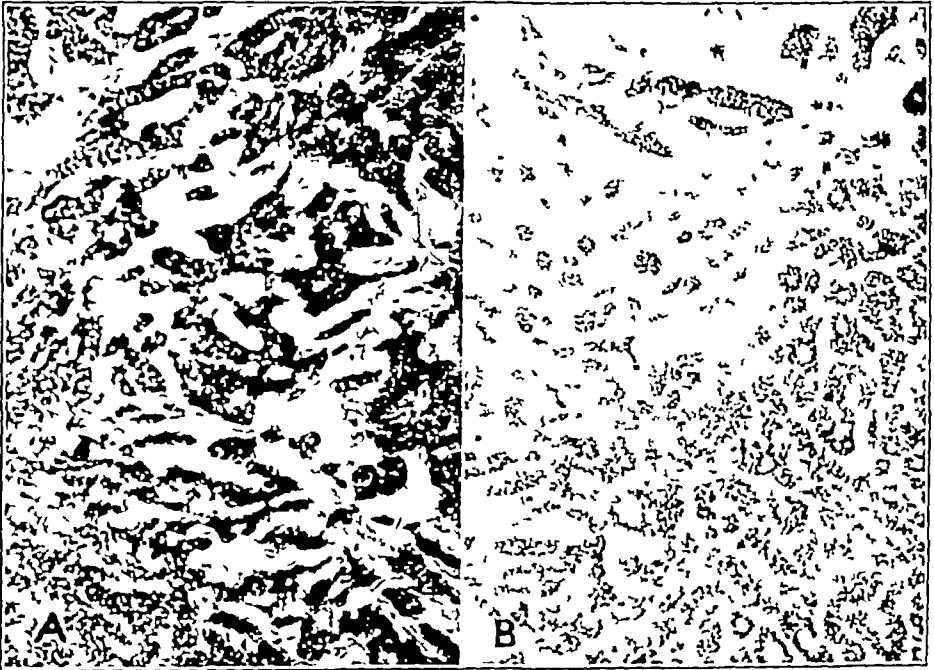


Fig 9—Comparison with figure 8, a mixed tumor of the submaxillary gland of eight years' duration *A* indicates an area near the periphery, *B*, an area near the center showing wide areas of mucoid material

vessel was an aneurysmal dilatation. In the upper lobe of the right lung and in the left lung no changes were found except aspiration of blood.

*Pathologic Anatomic Diagnosis*—The diagnosis was as follows: polypoid tumor of the main bronchus of the lower lobe of the right lung with partial occlusion of the lumen, multiple sacculated bronchiectases in the distal ramifications of the bronchus with bronchopleural fistulae, and rupture of an aneurysmal dilatation of a pulmonary artery branch with subsequent severe hemorrhage.

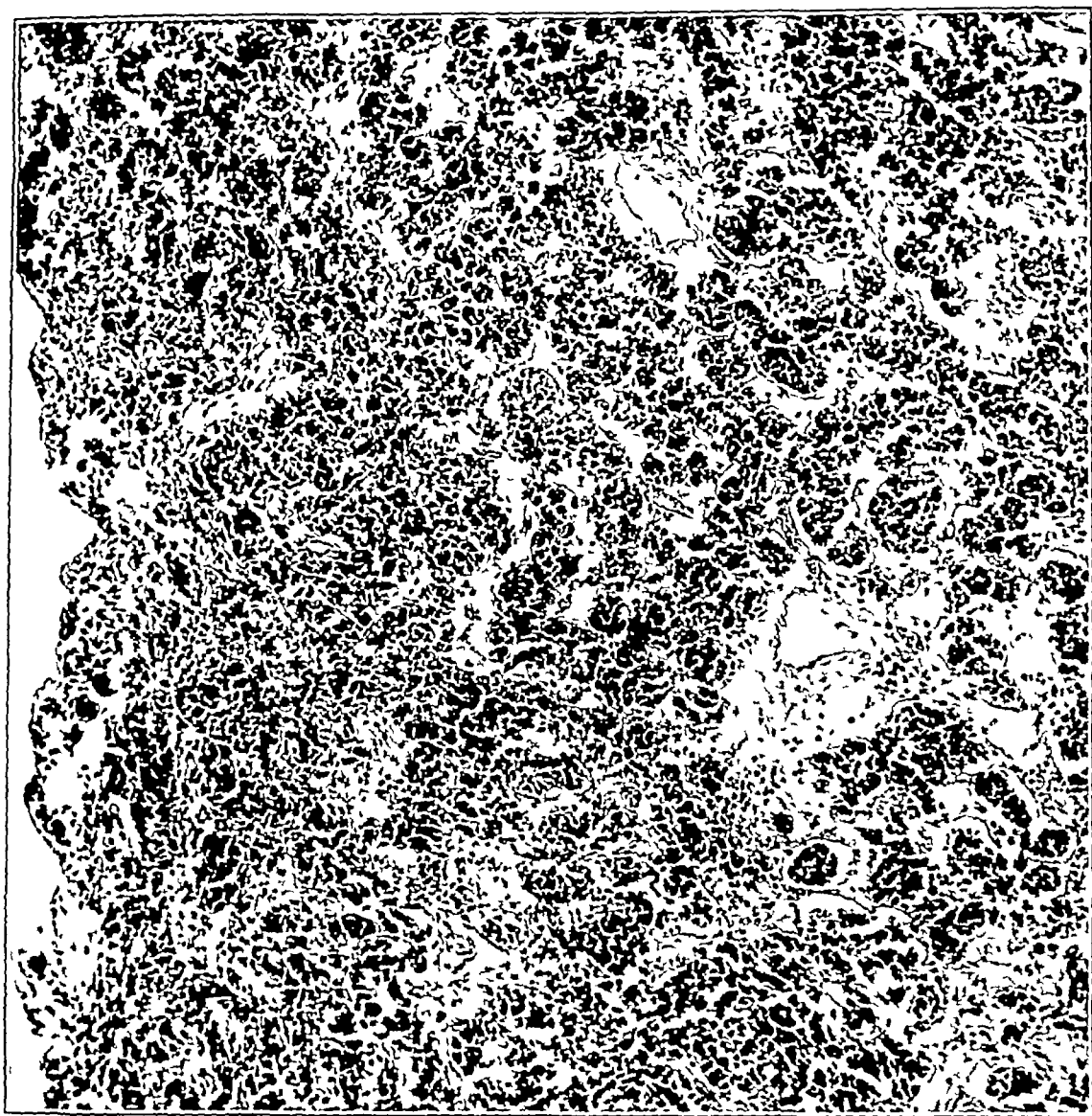


Fig 3—General view of the tumor showing its distinct glandular architecture,  $\times 40$

*Microscopic Examination of the Tumor*—Sections were taken from the surface as well as from the pedicle of the tumor. On the surface there was occasionally a stratified layer of squamous epithelium (fig 2), occasionally there was seen a single layer of columnar epithelium. Mostly, however, the surface was denuded of epithelium due to postmortem desquamation. The epithelium rested

Wolfler assumes that they result from the organization of blood clots. There is no evidence for this assumption. In the first place hemorrhages due to a pathologic process do not organize in a regular manner, because they do not form a true clot. Then, too, when blood clots do organize, they do not form bundles such as are seen here continuous with the normal struma of the gland. Furthermore the fibers of these masses are like the stroma of the tumors in tinctorial reaction. It appears fair to assume that for some reason the tissue forming the core of these tumors is prone to this keloidlike proliferation and forms an essential part of the life history of the tumor.

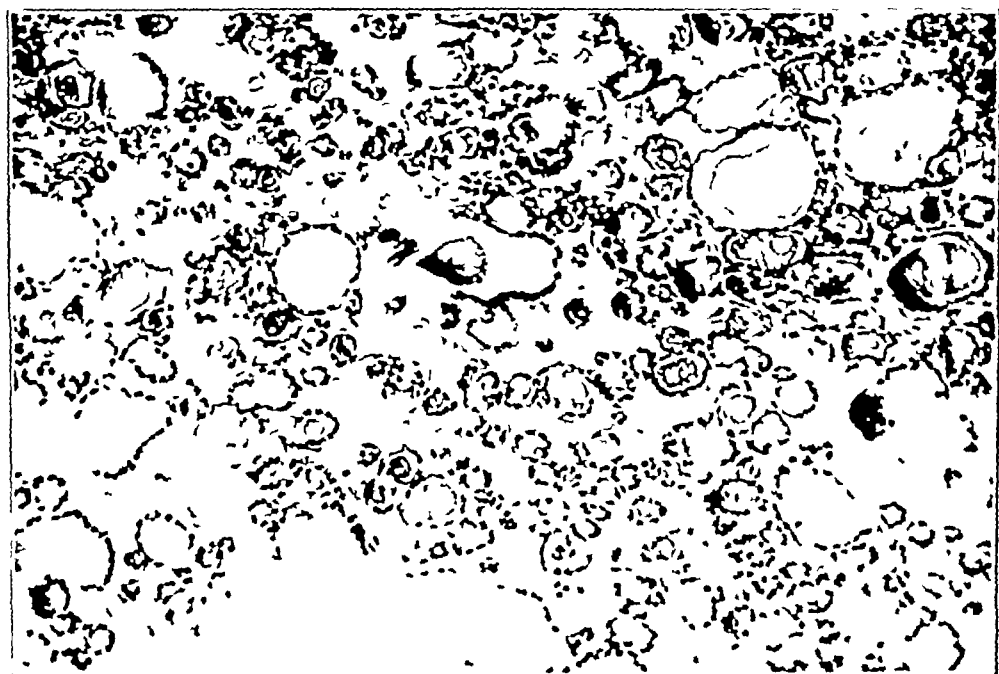


Fig. 10—Old mixed tumor showing large acini containing colloid. This patient had mild toxic symptoms.

The connective tissue between the acini undergoes a degeneration peculiar to these tumors. It becomes abundant and stains poorly, or not at all. The acini are sparse, isolated and often atrophic (fig. 12).

These tumors become larger in the course of time either by the formation of new acini with accumulated colloid or by the formation of connective tissue or both. In their terminal stages they may develop degenerative changes and become cystic through softening of the tissue with or without added hemorrhage. These tumors tend either to belated imitation of a colloid goiter by developing follicles and manifestation of hyperactivity or they tend to the formation of malignant tumors.

The gland may take on a belated development resembling a colloid goiter. The acini become large and filled with colloid, and the

the sections. The tumor appeared to be composed of round and oval alveoli epithelial cells which rest everywhere on a basement membrane, X 200  
 often intercommunicating and lined by columnar epithelium which contained a cylindrical rather dark nucleus. The cells rested on a basement membrane (fig 4) occasionally, the alveoli contained globular blue stained material, apparently mucus (fig 5). The stroma was composed of loose connective tissue and showed occasional infiltration with polymorphonuclear leukocytes, plasma cells and lymphocytes and contained numerous thin-walled blood vessels.

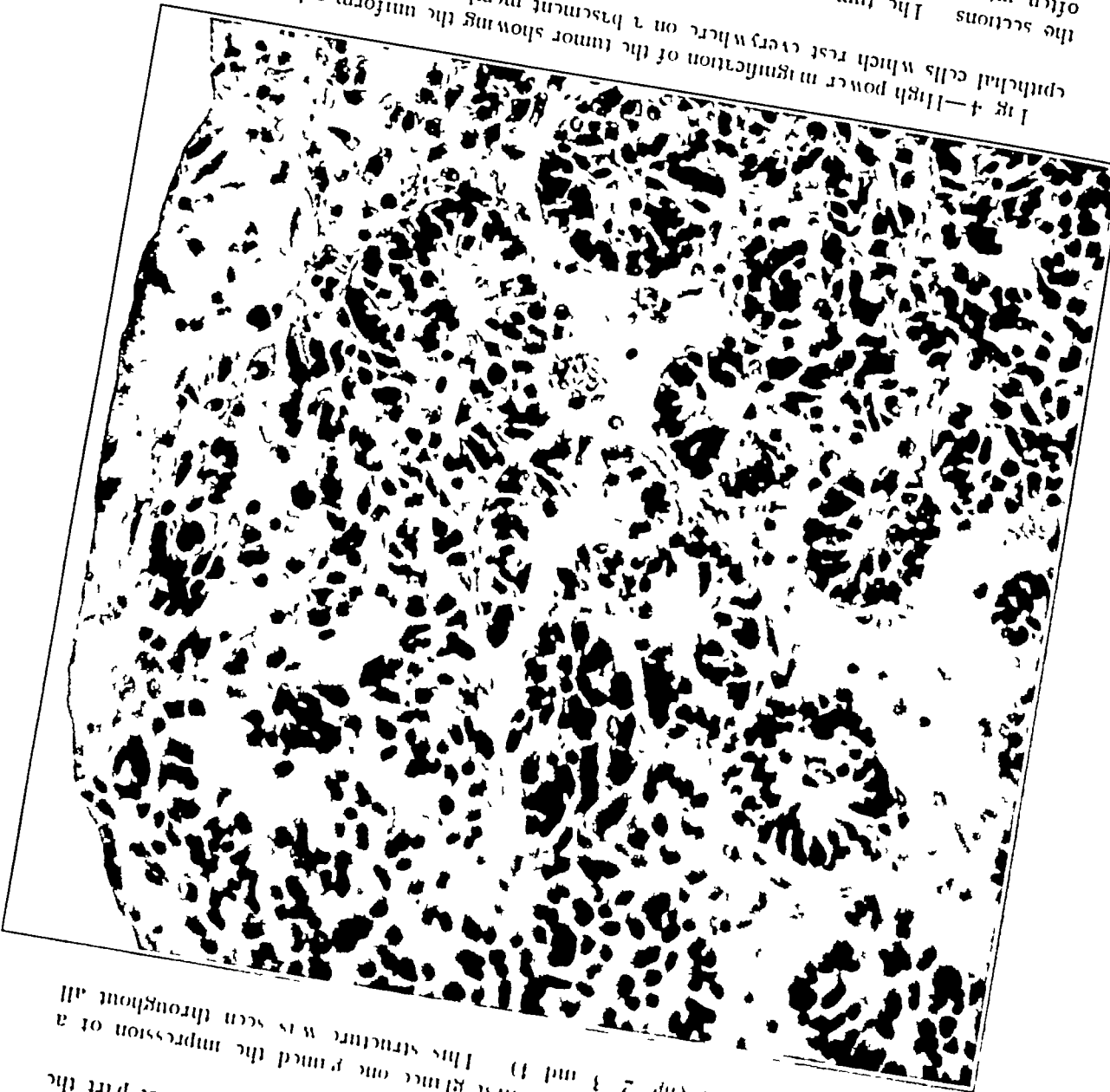


Fig 4—High power magnification of the tumor showing the uniform columnar epithelial cells which rest everywhere on a basement membrane, X 200  
 on a basal membrane which could be followed up along the entire circumference of the tumor except at the points where the cut section was carried. Beneath the basal membrane there was a rather wide layer composed mainly of elastic fibers. This layer however, could be seen only in a few places, for the most part the tumor extended up to the surface.  
 As to the tumor proper, at the first glance one found the impression of a glandular structure (fig 2, 3 and 4). This structure was seen throughout all



Fig 11—Area of the fibrous tissue core showing the heavy fibrin bundles. These fibers are seen to be continuous with the fibers extending between acini with mucoid areas between the fiber bundles (Mallory's phosphotungstic acid stain)



Fig 12—Slide showing some large acini filled with colloid together with many smaller ones. Between the acini are fine fibrils the interstices of which is occupied by mucoid material (Mallory's phosphotungstic acid stain)

On close examination, variations in the structure of the alveoli as well as variations in the cells could be seen distinctly. It was striking that the alveolar structure was more clearly demonstrated in the peripheral portion of the tumor than in the central one. While the cells in the peripheral portion were uniform in appearance, those in the central part differed considerably (fig 6), they were larger and contained large dark nuclei, the nucleocytoplasm ratio being altered to the disadvantage of the latter. Cells with two and more nuclei and occasional

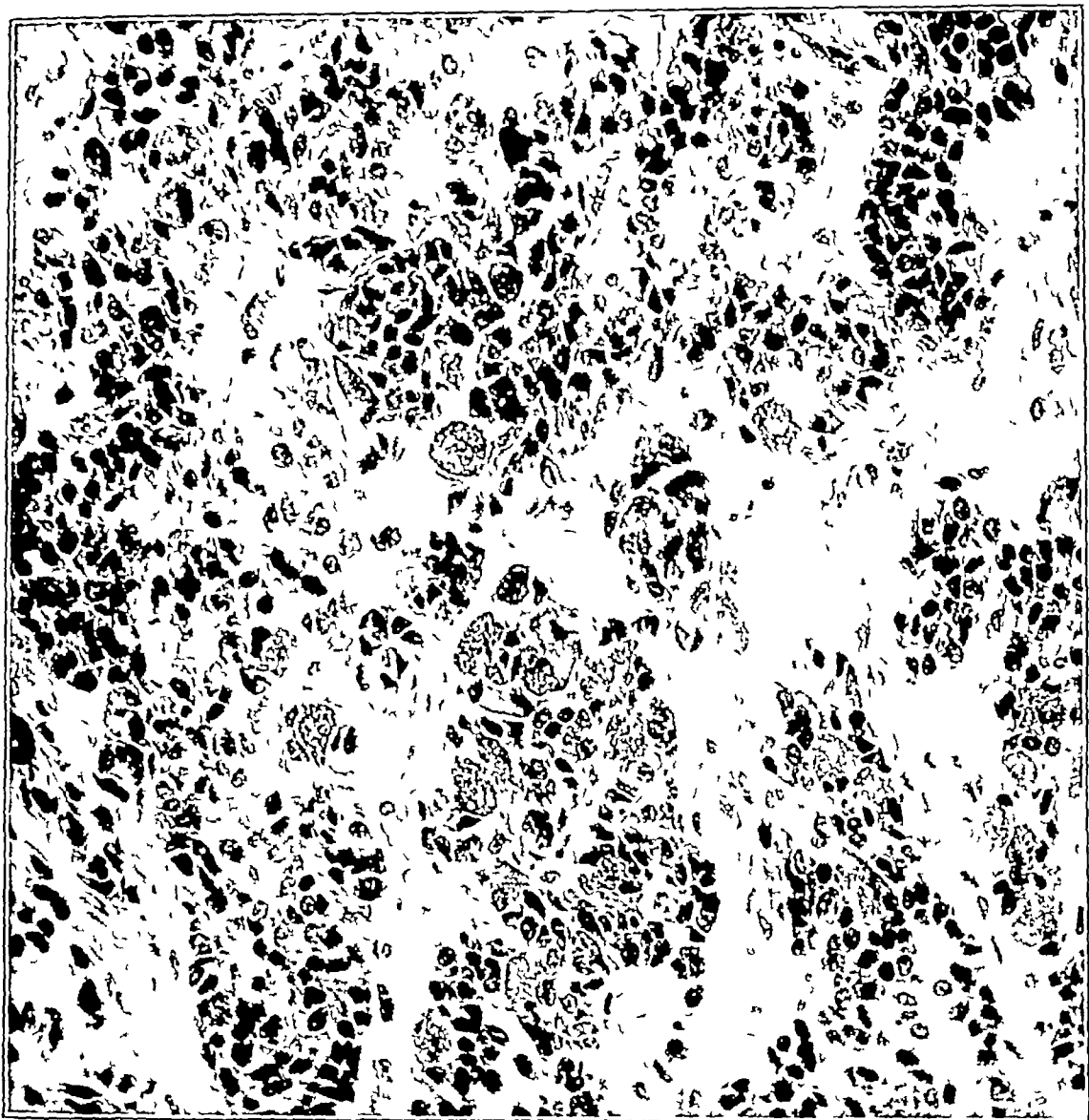


Fig 5—A portion of the tumor with mucus secretion within the alveoli,  $\times 160$

mitoses were found. Sections from the pedicle of the tumor did not show any infiltration of the bronchial wall.

From this description it can be concluded that the tumor originated from beneath the bronchial mucous membrane, since it was surrounded in its entire circumference by the basement membrane and the surface epithelium was still

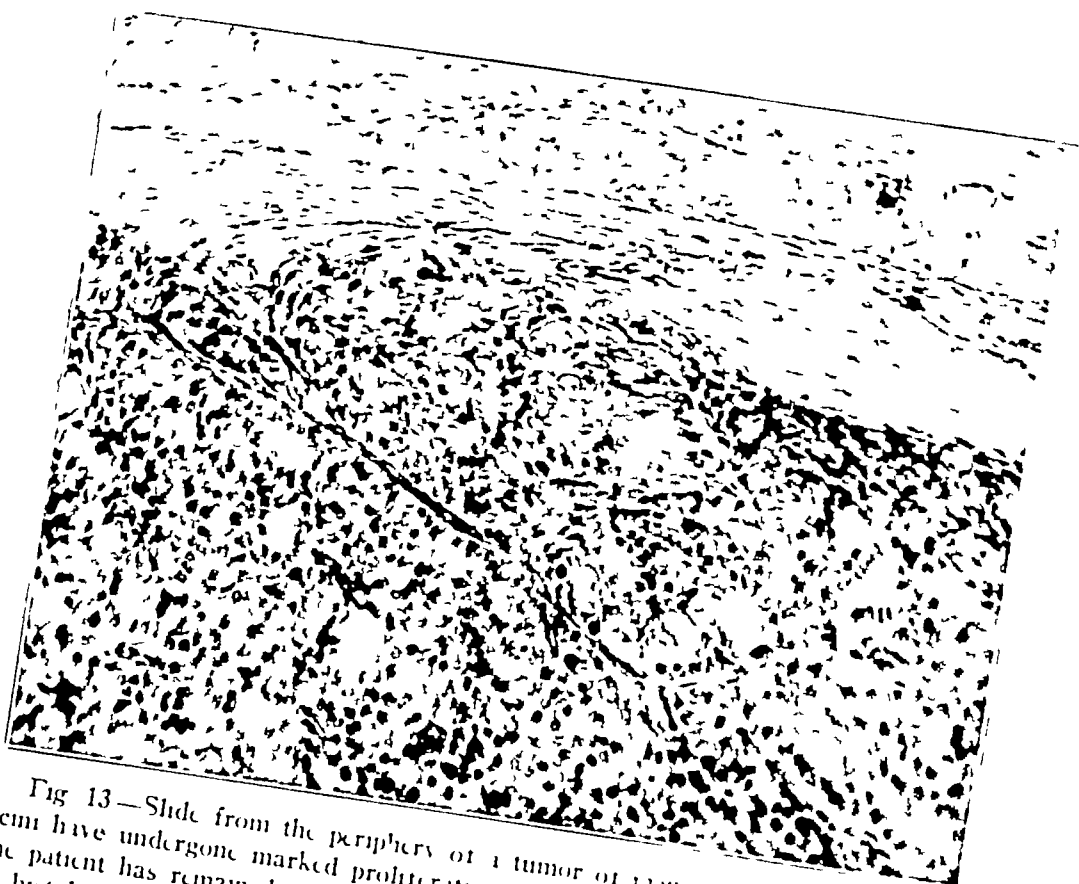


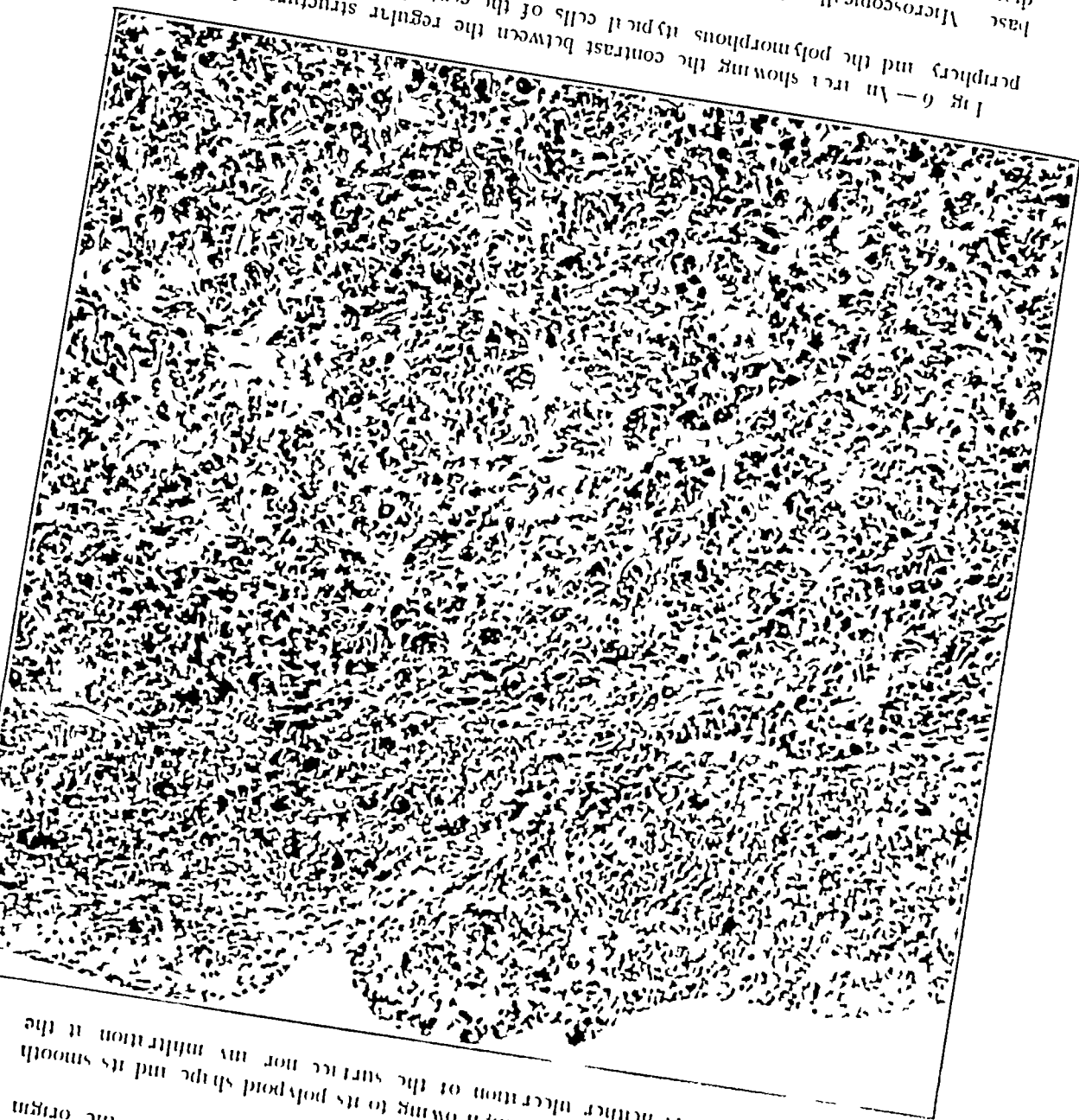
Fig 13—Slide from the periphery of a tumor of many years duration. The tumor have undergone marked proliferation. the capsule was not perforated and the patient has remained free from recurrence but the tumor must be regarded as histologically malignant





Fig 6 — An area showing the contrast between the regular structure of the periphery and the polymorphous typical cells of the central portions, X 40

base. Microscopically, the presence of the basement membrane supports the diagnosis of the benign nature. The deeper portions of the bronchial mucous membrane were compressed, but the basement membrane and the overlying epithelium was still preserved and nowhere had it been perforated. This pointed to an expansive and not an infiltrative growth, which was also in accord with



Grossly, the tumor appeared benign owing to its polypoid shape and its smooth surface, there was neither ulceration of the surface nor any infiltration at the from the excretory ducts. Therefore it might have originated either from the mucous glands or from their excretory ducts. The columnar shape of the cells composing the alveoli and the fact that only occasional accumulations of mucus are encountered and the intercommunication of the alveoli, speak in favor of the origin preserved in places. Therefore it might have originated either from the mucous glands or from their excretory ducts. The columnar shape of the cells composing the alveoli and the fact that only occasional accumulations of mucus are encountered and the intercommunication of the alveoli, speak in favor of the origin

and new acini may form (fig 10), the acinal epithelium may even become columnar in rare cases. The colloid never loses its staining characters, nor is there ever any papillation. In other words, these never take on the characteristics of exophthalmic goiter secondarily. Together with these acinal changes, the connective tissue always shows the foregoing peculiar changes, so that there still remains some justification for calling these tumors mixed tumors.

In the second type, the cell columns develop and come to resemble an adenocarcinoma in form. This may occur as rapidly-forming acini (fig 13) or by forming long columns (fig 14). This is the type

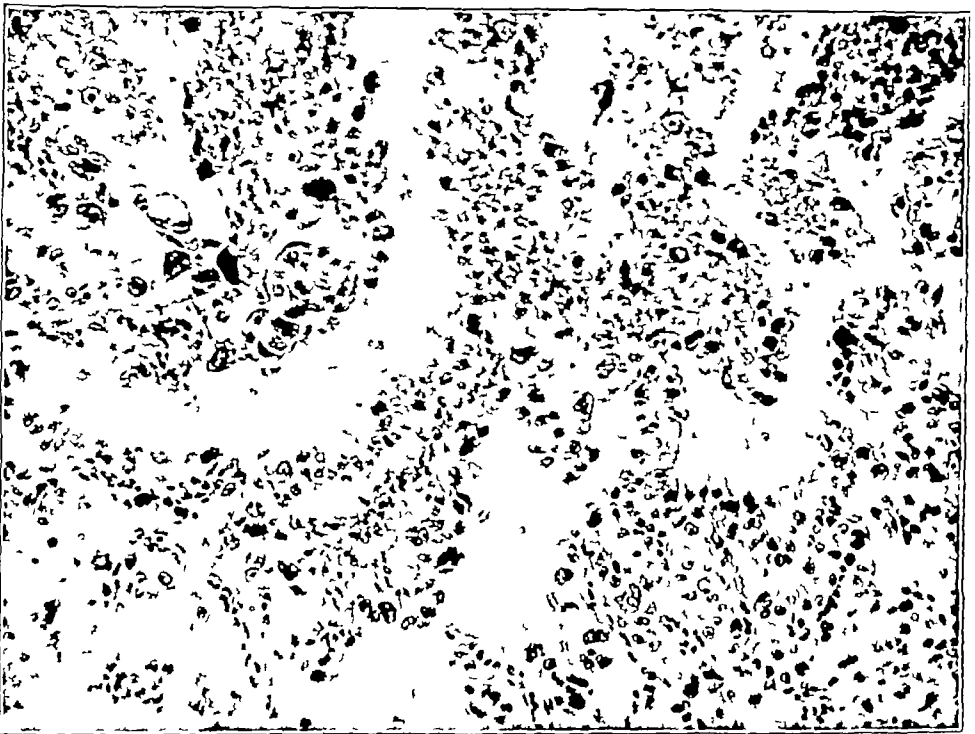


Fig 15—The acinal arrangement has been lost. A complete lobectomy removing all obvious tumor tissue failed to cure the patient.

that the laboratory worker is prone to diagnosticate as malignant. The type of connective tissue degeneration which forms a part of the life history of these tumors is strikingly like that seen in artificial tumors (produced by sudan III, tar, etc) and in the initial stages in roentgen-ray epitheliomas. It seems the part of wisdom to regard these tumors as at least potentially malignant when they show epithelial activity, and to govern the therapeutic activities accordingly. The mere fact that permanent cure follows their removal, in most instances before the capsule is invaded, does not invalidate this point of view. The fact remains that when distant metastases occur, this type of lesion is nearly always the cause. Most of the local malignancies are caused

the mode of growth of a benign tumor. The uniformity in the morphology of the tumor cells forming the alveoli which was found within the greater portion of the tumor was also a point in favor of its benign nature. The distinct morphologic variations in the appearance of the cells in the central portions of the tumor, the alteration of the nucleocytoplasm ratio, the hyperchromatic nuclei and the occasional mitotic figures, however, are features that speak in favor of malignant transformation.

The histologic opinion, therefore, was that of a benign adenoma originating from the epithelium of the excretory ducts of the bronchial mucous glands, but containing portions that exhibited a precipitate proliferation with signs of immaturity and anaplasia.

## COMMENT

The case reported here is that of a woman, aged 47, who had suffered for several years from symptoms of a respiratory disease associated with cough and expectoration, and had been repeatedly operated on for empyema in the right side of the chest. Since the symptoms continued she was admitted to the hospital where a cavity in the base of the right lung was found. An operation which was attempted to bring about the collapse of the cavity had to be discontinued on account of a profuse hemorrhage from the wound. After a short period of apparent improvement, another profuse hemorrhage from the wound was followed by almost immediate death. Autopsy revealed a polypoid growth springing off the wall of the main bronchus of the lower lobe of the right lung grossly showing definite benign characteristics, histologically an adenoma with features that make a malignant transformation in the center of the tumor probable. Numerous sacculated bronchiectatic cavities were present within the lower lobe of the right lung distal to the seat of the tumor, one of which opened directly on the surface of the lung and showed a communication with the sinus in the thoracic wall. An erosion of a branch of the pulmonary artery was found within one of the bronchiectases with a terminal hemorrhage from that vessel.

In correlating the postmortem observations with the clinical course of the disease, it appears evident that the symptoms were due to the extensive bronchiectases in the lower lobe of the right lung. The condition diagnosed as empyema was probably the result of the extension of the suppurative process from the bronchiectases into the pleural space, particularly, the cavity opening directly on the surface of the lung can be looked on as a continuous source of maintaining the suppurative process in the thoracic cavity. The final cause of death was the profuse terminal hemorrhage from the eroded branch of the pulmonary artery. It can be said, therefore, that the occluding polypoid tumor in the bronchus of the lower lobe of the right lung which caused the development of the bronchiectases (the mechanism of which will be discussed later) was undoubtedly responsible for the entire course of illness as well as for the final cause of death. The protracted course of the disease,

by these tumors. Like the mixed tumors of the salivary glands, these tumors tend ultimately to become malignant. It is only when this fact is recognized that one learns to appreciate the inherent tendency of these tumors.

#### COMMENT

It is important to emphasize that the tumors are not influenced by medication. This is easy enough to understand when it is remembered that the acini contain little if any colloid. While medication may influence the character of the cells after a prolonged period by causing change in the colloid, it cannot influence the connective tissue framework. This fact seems to have been overlooked by recent students of the influence of compound solution of iodine on toxic glands. Therefore, when one of these nodules is encountered, it should be removed or ignored. The patient may be assured that the removal of the tumor will be necessary some time. The objection to the removal of the tumors in young persons is that a true goiter may develop in later years which will be looked on by the patient as a recurrence. In such cases, it is well to acquaint the patient with this possibility. If treatment is being given for an early colloid goiter which harbors one of the mixed tumors, it is well to tell the patient that while the goiter as a whole will disappear, the nodule will remain unchanged though it may be less conspicuous by virtue of greater space being provided by the regression of the goiter.

Patients with mixed tumors may be assured that when these tumors become toxic, the toxicity is not extreme and that eye signs are never produced. These facts may be told patients in the first half of life.

When middle age is approached, while the foregoing facts may be admitted, it must be emphasized that the danger of late heart degeneration, and particularly the development of malignancy, is ever present and that removal of the tumor is to be urgently recommended.

Furthermore, when these tumors attain considerable size, associated with secondary degeneration, hemorrhage into them occurs, this may result in pronounced inflammation of the capsule and the surrounding tissue and painful affliction. Such a hemorrhage is far more serious when the tumor is associated with a colloid goiter or when it is located in the thorax. In such cases, the sudden regeneration rate of the tumor may quickly suffocate the patient.

For these reasons, the mixed tumors of the thyroid should be looked on as true neoplasms and not as goiter. While the tumors are benign in the earlier stages and allow a certain degree of delay in treatment, they will cause trouble sooner or later. In the end, in this, they differ from the benign colloid goiter. The mixed tumors, not like those of the salivary glands, are not

extending as it did for a period of several years, is consistent with the presence of a benign tumor. The malignant changes revealed by the histologic examination can be regarded as of late occurrence and without significance for the clinical picture and the final events.

# REVIEW OF LITERATURE

A survey of the literature in regard to intrabronchial new growth of epithelial origin reveals only a few cases that show features similar to the case here reported. In the case of Mueller,<sup>1</sup> a clinically benign pedunculated adenoma with partial calcification was found in the main bronchus of the left lung causing a partial occlusion of the lumen. Numerous sacculated bronchiectatic cavities filled with purulent and food material were present distal to the seat of the tumor. This case was that of a young woman, aged 22, who had suffered for a period of eight years from profuse expectoration of bloody and food material. The origin of this tumor was attributed to proliferation of the bronchial mucous glands. Another case of an epithelial polypoid tumor, which was considered as a cylindrical cell carcinoma originating from aberrant epithelium was found by Kreglinger<sup>2</sup> in the main bronchus of the left lung giving rise to almost complete obstruction of the lumen and atelectasis of the lung. In this case there was a history of massive expectorations for a period of six years, and numerous bronchial dilations could be demonstrated at autopsy. In view of the course of the disease, it seems justifiable to assume that originally this tumor was benign. Kirch<sup>3</sup> reported a case of a polypoid tumor in the main bronchus of the left lung with diffuse sacculated dilations of the distal bronchi, the histologic opinion was that of an originally benign fibromatous polyp with late malignant proliferation and tendency to infiltrative growth. A polypoid tumor in the main bronchus of the right lung located in close proximity to the lower lobe branch with extensive bronchiectases in the lower lobe of the right lung, was observed by Fleck<sup>4</sup> Malkwitz<sup>5</sup> reported a case of a primary polypoid tumor in the main bronchus of the left lung. Both these cases however, presented definite malignant features with infiltration of the bronchial wall, and in both cases the origin was attributed to congenitally aberrant epithelium. A true

- 1 Mueller, Heinrich. Zur Histologiegeschichte der Bronchiektaserweiterungen, Inaug. Diss., Halle 1/5 1882.
- 2 Kreglinger, G. Ueber ein primäres Bronchiektasizom, Frankfurter Zeitschr. f. Pathol. 12 135 1913.
- 3 Kirch, Eugen. Ueber stenosierende Bronchiektasizulste mit konsekutiver Bronchiektasienbildung Centralbl. f. allg. Pathol. u. pathol. Anat. 28 545, 1917.
- 4 Fleck, Willi. Ueber primäres polypöses Bronchiektasizom, Inaug. Diss., Bonn, 1916.
- 5 Malkwitz, Frieda. Beitrag zur Kenntnis polypöser Bronchiektasizome, Frankf. Zeitschr. f. Pathol. 26 189, 1922.

would, therefore, be expected that the cycle of pathologic changes would be the same, whether the disease process were limited to certain regions or spread diffusely through the gland as a whole. These localized areas would become enlarged in a similar manner as a result of hypertrophy and hyperplasia in the active phase, and as a result of involution with the deposition of colloid and fibrous tissue in the inactive phase. Thus the greater the number of the disease cycles, the larger these nodules would become. It is not clear why only certain localized areas of the parenchyma become hyperactive in some cases while in others the entire gland is involved. When the pathologic process has begun the active phases (hypertrophy and hyperplasia) and the inactive phase (involution) of the disease cycle are attended by their characteristic histologic changes. It is possible that these localized areas of hyperfunctioning parenchyma originally may have been normal areas or lobules of the parenchyma of the gland which has undergone a pathologic hyperplasia, or, as suggested by Dr. Arnold Rich,<sup>3</sup> these areas may have originated in small isolated portions of the parenchyma commonly observed in the suprarenal and liver. In one part of his discussion on adenomas MacCallum<sup>4</sup> says "The thyroid adenomata are extremely common and here again it is sometimes difficult to feel sure that we are dealing with actual tumors and not with hypertrophy of the functioning gland." A similar opinion is expressed about the liver, suprarenal and other solid glandular organs. It is true that hypertrophy and hyperplasia of the thyroid gland may be encountered in conditions other than hyperthyroidism, such as the diffuse compensatory hypertrophy and hyperplasia seen in myxedema and in cretinism, and that produced experimentally in animals but we have never encountered a case of clinical hyperthyroidism in which hypertrophy and hyperplasia of the thyroid parenchyma could not be readily demonstrated. In the large hyperplastic nodular goiters of patients in whom the rate of basal metabolism is below normal and in whom the clinical picture is that of hypothyroidism, it is often possible to find histologic evidence of hyperactivity in certain limited regions. These areas which show slight hypertrophy and hyperplasia, are usually infrequent and irregularly irregularly throughout a gland which has the microscopic appearance of extreme histologic involution, evidenced by the presence of large areas of dilated, colloid-containing acini and which presents the macroscopic picture of a simple colloid goiter. It would seem likely that such areas represent more actively functioning parenchyma or even foci of regenerative hypertrophy and hyperplasia of an otherwise inactive

<sup>3</sup> Rich A R Personal communication to the author.  
<sup>4</sup> MacCallum W G The Pathology of the Liver, 1928, p. 107.  
 49 1138 (Oct 2) 1907 MacCallum's Pathology, 1907, p. 107.

gland, the hypertrophy and hyperplasia being compensatory here also. These points are brought out to demonstrate that mere hypertrophy and hyperplasia in a thyroid gland are not diagnostic of a clinical hyperthyroidism, since the hypertrophy and hyperplasia may be of a compensatory nature, either diffuse as in cretinism or regional as in hyperinvoluted nodular thyroids or colloid goiters. The point which we wish to emphasize, however, is that, given hyperthyroidism clinically, one always finds hypertrophy and hyperplasia of the thyroid parenchyma regardless of whether the gland is clinically nodular or the process is diffuse. In view of the fact that the hypertrophy and hyperplasia of the gland which invariably accompany clinical hyperthyroidism cannot always be distinguished histologically from the hypertrophy and hyperplasia of a compensatory type, attempts to draw clinical deductions from microscopic sections may lead to incorrect conclusions in many instances. The clinical syndrome must be carefully studied with the pathologic manifestations. Of the nine cases (8 per cent of 109) in which true benign neoplasms occurred in the thyroid concomitantly with a diffuse hypertrophy and hyperplasia of the gland as a whole, it may be said that this probably represents the normal incidence of true benign neoplasms in cases of nodular goiter. It would seem unlikely that these true tumors played any rôle in the production of the hyperthyroidism, and so far as this study is concerned, no functional significance can be attributed to their presence.

#### SUMMARY

Studies of the involutional changes occurring in the thyroid glands of patients with exophthalmic goiter who were undergoing remission following treatment with iodine revealed striking similarities to the histologic picture encountered in nodular goiter. When analyzed in connection with the involutional bodies, the pathogenesis of nodular goiter in about 92 per cent of the cases becomes evident. It was shown that a clinically typical case of exophthalmic goiter associated with a diffuse, smooth enlargement of the thyroid gland due to hypertrophy and hyperplasia of the parenchyma can give rise to a nodular goiter as a result of involutional changes in the thyroid concomitant with an artificial or spontaneous remission. These nodules or involutional bodies are not neoplasms in any sense of the word, but are merely regressive sequelae of a previous hypertrophy and hyperplasia of the parenchyma. Their number and size depend on the number of remissions and exacerbations in that gland. They are the products of a diffuse hypertrophy and hyperplasia of the thyroid, and it is likely that similar involutional changes occur in the breast and ovary or in other glands of flux. Thirty-four per cent of the cases in this study belong to this group.

polypoid adenoma in the main bronchus of the middle lobe of the right lung with complete obstruction of the lumen and cylindrical bronchiectases of the distal bronchial ramifications has recently been described by Heine,<sup>6</sup> the origin of this tumor is not definitely stated, both the surface epithelium of the bronchus and the epithelium lining the excretory ducts of the bronchial mucous glands are considered as possibilities.

From the foregoing cases, it appears evident that bronchial dilatations were almost invariably encountered in these cases of occluding intrabronchial neoplasms. Indeed, since the thorough investigations of Biermer<sup>7</sup> on the pathogenesis of bronchial dilatations, it is well established that intrabronchial tumors occluding the lumen may give rise to development of extensive dilatations of the distal bronchial ramifications. According to Biermer, the disturbance of the respiratory mechanism leading to an increase in the expiratory intrabronchial pressure is the factor primarily responsible for the development of the bronchiectases. It is the valvelike action of the occluding growth that affects the expiration much sooner and to a greater extent than the inspiration, which may for a considerable length of time go on undisturbed. The persistent cough driving the air from the surrounding alveoli into the bronchi under forced pressure is again a factor which increases the expiratory intrabronchial tension and which places a strain on the bronchial wall and leads to a gradual weakening of the elastic tissue. The ground for the dilatation appears well prepared and since hypersecretion is usually present in these bronchi, the accumulation of the secretion soon causes inflammatory changes which damage still more the contractile and elastic elements of the bronchial wall, so that finally no force is left that would counteract the dilating factors. If this process goes on for a sufficient length of time the inflammation may spread to the parenchyma of the lung, and as a result of this the normal elasticity of the lung is diminished or lost. As the lung is then not able to follow sufficiently the expansion of the chest during inspiration, an increased traction is exerted on it by the increased inspiratory negative pressure. This ultimately may act as an extrabronchial factor favoring the dilation of the bronchi.

Biermer's conception of the mechanism and the pathogenesis of bronchiectases distal from the point of bronchial occlusion seems to be well illustrated by the type of tumors with which we are dealing here. The well circumscribed pedunculated tumor endowed with more or less mobility appears particularly fit to reproduce the mechanism with its valvelike action. This is especially true for the slow growing benign

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6 Heine, J. Ueber eine primäre gestielte Bronchialgeschwulst, *Verhandl der deutschen pathol Gesell* **22** 293, 1927.

7 Biermer. Zur Theorie und Anatomie der Bronchienerweiterung, *Virchows Arch f path anat* **19** 94, 1860, *ibid*, **19** 241, 1860.



plexus can be seen beneath the floor of the region through the trans-parent prevertebral fascia and do not in any way belong in this space. (b) The Posterior Compartment or the Posterior Cervical Triangle. The posterior compartment is a triangle bounded posteriorly by the trapezius muscle, anteriorly by the sternocleidomastoid muscle, and inferiorly by the clavicle. Its floor or posterior wall is made up of the prevertebral fascia, a continuation of the floor of the sternocleidomastoid region. The areolar lymph gland bearing tissue, which, for the most part, makes up the contents of this compartment comprises glands of the superior deep cervical chain as well as inferior deep cervical systems draining the axilla and mediastinum. The glands of these two deep

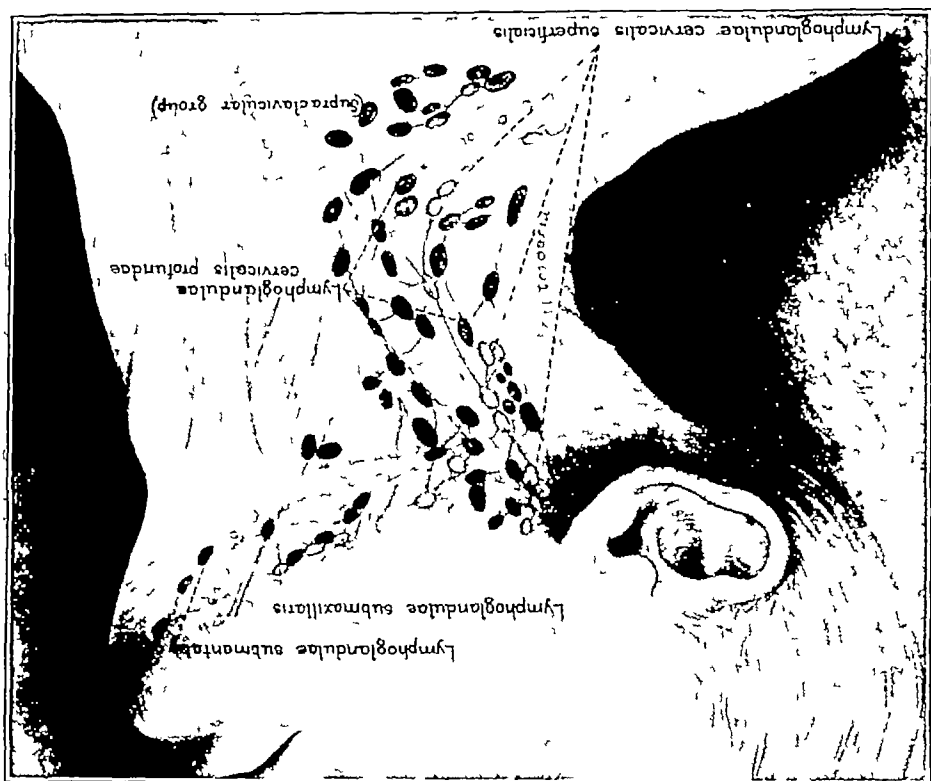


Fig. 4—Schematic drawing to represent the distribution of the lymphatic gland chains of the neck and their relationship to one another and the neighboring structures. The deeper glands of the cervical chain are the ones primarily involved in carcinoma of the tongue. Note the close relationship between these glands and the internal jugular vein, the highest glands lying against the vein at the base of the skull and embedded in the lower pole of the parotid gland, the lowest gland at the lower edge of the omohyoid muscle as it crosses the vein, and the barren zone between this group and the suprahyoid chains constituting a break between the deep cervical glands and the supraclavical chains. The suprahyoid chains are primarily involved in carcinoma of the lip. The glands first affected are usually those lying against the ramus of the jaw along the edge of the sub-mandibular salivary gland and those at the apex of the submental triangle just beneath the point of the chin.

tumor without tendency to infiltration, but with a decided occluding growth which may exist for a considerable length of time as a silent tumor without causing symptoms of great significance. The cases in which only partial occlusion of the bronchus existed seem to illustrate this mechanism much clearer than the cases of complete bronchial obstruction. If a bronchus has been completely occluded at a relatively early period of the existence of the tumor, the possibilities for the development of bronchiectases become slight since the particular portion of the lung supplied by this bronchus loses its function completely and becomes atelectatic.

It is therefore the tendency to gradual occlusion of the lumen and the noninfiltrative growth that explains the fact that benign tumors in the bronchi are usually found associated with extensive bronchiectases. In addition to the foregoing cases of epithelial tumors there have been recorded several cases of benign occluding intrabronchial neoplasms of nonepithelial origin. A case is mentioned by Rokitsky<sup>8</sup> in which a lipoma in the main bronchus of the lower lobe of the left lung obstructed the lumen almost completely, the distal bronchial branches were dilated and the lower lobe of the left lung collapsed. Radestock<sup>9</sup> reported a rather unusual case of an obstructing tumor of the main bronchus of the right lung with numerous bronchial dilatations and a cavity opening directly on the surface of the lung. Histologically, the tumor proved to be composed of thyroid tissue and its origin attributed to an aberrant thyroid. Siegert<sup>10</sup> reported a case of a chondroma within a branch of the bronchus of middle lobe of the right lung and Blecher<sup>11</sup> a case of a pedunculated ossified chondroma in the main bronchus of the left lung near the bifurcation, both of these cases presented numerous cylindrical bronchiectases distal from the seat of the tumor. A case of a pedunculated fibroma in the bronchus of the lower lobe of the right lung with cylindrical bronchiectases was described by Knack<sup>12</sup>. A lipomalike tumor in a branch of the bronchus of the middle lobe of the right lung was reported by Feller<sup>13</sup>.

8 Rokitsky, Carl. *Lehrbuch der pathologischen Anatomie*, 1861, vol 3, p. 25.

9 Radestock. Ein Fall von Struma intratrachealis, *Beitr z pathol Anat* 3: 289, 1888.

10 Siegert. Ueber primäre Geschwulste der unteren Luftwege, *Virchows Arch f path anat* 129: 413, 1892.

11 Blecher. Ueber die klinische Bedeutung der Bronchialechondrosen, *Mitt a d Grenzgeb d Med Chir* 21: 837, 1910.

12 Knack. Ein Fall von Bronchiektasenbildung infolge eines Fibroms an der Abgangsstelle des unteren Hauptbronchus, *Deutsche med Wchnschr* 44: 1007, 1918.

13 Feller, Adolf. Ueber ein lipomähnliches Hamartom der Lunge, *Virchows Arch f path Anat* 236: 470, 1922.

cervical chains are separated by the posterior belly of the omohyoid muscle. The only important other structure in that area of the compartment superior to the omohyoid muscle is the spinal accessory nerve. This nerve runs a variable course from the posterior edge of the sternocleidomastoid muscle to the anterior border of the trapezius. The important structures in the area inferior to the omohyoid muscles are the subclavian artery and vein and several large branches of the axromi-thoracic trunk. Other vitally important structures of the neck are not occupants of this compartment, i. e., the cords of the brachial plexus as they emerge from the interval between the scalenus anticus and the scalenus medius muscle, the phrenic nerve, the inferior thyroid artery and the sympathetic chain, for these structures lie deep to the prevertebral fascia and, therefore, beneath the floor of the region.

#### SURGICAL DISSSECTION OF THE SUPRAPHYOID REGION

*Indication*—The suprahyoid dissection, independent of the dissection of the lateral region of the neck, is used for metastatic carcinoma of the hip when the indications for the complete dissection of the neck are lacking, that is, when gross examination of the submental and submandibular glands, at operation, do not show evidence of metastases. A complete or a combined dissection of the neck is necessary when there is gross involvement of the submandibular or submental groups. This follows from the general rule regarding metastatic carcinoma that secondarily chains must be removed where there is gross involvement of the primary chains. Seldom, however, does carcinoma of the hip require more than the simple operation on the suprahyoid region.

The uncombined, or the pure suprahyoid dissection of the neck is often a bilateral procedure, because usually the lesion of the hip crosses the midline or is near the midline. The bilateral dissection adds little to the operation and it gives the patient a symmetric neck. This procedure should follow the resection of the local primary lesion as soon as convenient, and always within a few weeks, providing the microscopic study of the primary lesion shows a growth of sufficient extent to have infiltrated the muscle of the hip or in any case regardless of the extent of the growth where there is a total lack of differentiation of cells (Broders).

*Method of Procedure*—A cut throat incision is employed (Fig. 25) extending from mastoid process to mastoid process and passing across the front part of the throat just above the hyoid bone. This incision is divided at a central suprathyoid dissection alone is contemplated and then extends from the mastoid process only a short distance across the middle to the mastoid process. The opposite dissection is an incision on the corner of the hyoid bone. The suprahyoid is dissected up taking a very thin and a very thin tissue while the inferior hip is dissected. The inferior hip is dissected up the incision of the hyoid bone and the lower part of the neck.

Those rare cases of tumor development in cases of bronchiectases of long standing, such as those reported by Chiari,<sup>14</sup> must be regarded as a different entity. In a case of diffuse chronic tuberculosis of both lungs with occasional sacculated bronchiectases, he observed a tumor in one of the cavities which histologically proved to be a proliferating adenoma originating from the bronchial mucous glands. The other case of Chiari was that of a mixed tumor, a lipochondro-adenoma in an old sacculated bronchiectatic cavity. These tumors are to be considered as secondary to the bronchiectases being the sequel and not the cause of the latter. Such tumors, according to Chiari, may develop in the course of the dilatation of the bronchi in a similar manner as proliferation of the papillary type commonly found in old bronchiectases.

The fact that extensive bronchiectases are less frequently found in cases of malignant bronchial tumors is explained by their more rapid growth, the metastases and the general deleterious effect on the organism which usually cause death long before there is sufficient time to develop bronchiectases. The ulceration and the degenerative changes which these tumors frequently undergo may also be a factor in preventing a marked degree of bronchial occlusion. Occasionally, however, marked bronchiectases are seen in malignant neoplasms, particularly in the nodular or papillary form as in the cases of Biermer,<sup>7</sup> Muethler<sup>15</sup> and Reiche<sup>16</sup>.

We mentioned at the outset the importance of bronchoscopy as a valuable diagnostic aid in intrabronchial neoplasm. Reports in the literature indicate that there is also a therapeutic field for this method, particularly in cases of benign tumors. Spiess<sup>17</sup> removed a polypoid tumor of the main bronchus of the right lung lodged just at the bifurcation by means of the bronchoscope after tracheotomy had been performed. The patient who had suffered from severe dyspnea with attacks of suffocation showed marked improvement. An endothelioma of the main bronchus of the right lung was removed by Jackson<sup>18</sup> by means of peroral bronchoscopy and the patient observed for one and one-half years as free from symptoms. Pfeiffer<sup>19</sup> used the same method in

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14 Chiari. Zur Kenntnis der Bronchialgeschwulste, Prag med Wchnschr 8 497, 1883

15 Muethler, Gustav. Ein Fall von Bronchostenose durch ein Sarkom bedingt, Inaug. Dissertation, Berlin, 1873

16 Reiche, F. Primäres Tracheakarzinom, Metastase in der linken Nebenniere, Melasma suprarenale, Centralbl f allg Pathol u pathol Anat 4 1, 1893

17 Spiess, Gustav. Ein Fall von hochgradiger Dyspnoe infolge eines Polypen im rechten Bronchus, München med Wchnschr no 40, p 2095, 1910

18 Jackson, Chevalier. Endothelioma of the Right Bronchus Removed by Peroral Bronchoscopy, Am J Med Sc 153 371 (March) 1917

19 Pfeiffer, Willy. Das Jacobson-Holzknicht'sche Phänomen bei einseitiger Bronchostenose und seine künstliche Erzeugung, Deutsche med Wchnschr no 47, p 1298, 1920

This lays bare the contents of the triangles to be dissected, covered by the enveloping fascia. With a sharp blade this fascia is divided all along the anterior border of the mandible and over the parotid gland from chin to sternocleidomastoid muscle. By a "wiping down" process or blunt dissection, the separation of the glandular and areolar contents from the periosteum of the bone, from the parotid gland, and from the outer surface of the mylohyoid and hyoglossus muscles is accomplished. This cleaning-out process is early held up by the facial vessels, which must be ligated and cut where they pass over the horizontal ramus of the jaw (fig 6). At this point, one proceeds with caution until the marginal branch of the mandibular nerve (seventh) is isolated and retracted out of danger. This nerve can be located best and traced out by picking it up as it comes across the ramus of the jaw together with the facial vessels (*Mallarius externa*). The destruction of this nerve means a permanent paralysis of the lower angle of the mouth. The "wiping down" process may now continue with the cleaning off of the outer surfaces of the

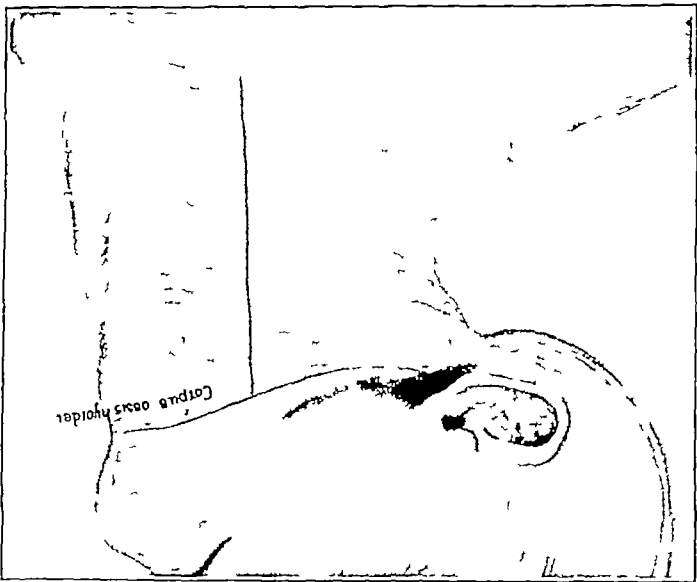


Fig 5—Incisions employed for dissections of the neck. The horizontal line represents the incision for suprahyoid unilateral dissection. It extends from the mastoid to the anterior belly of the digastricus of the opposite side. It lies in a natural fold of the neck and passes just above the hyoid bone. Deviation from this line should not be made regardless of possible wrinkles, as this always gives the best cosmetic result. The upper flap only is lifted. The vertical line represents the incision for the lateral dissection. It extends from the middle of the horizontal incision and strikes the clavicle just lateral to the sternocleidomastoid muscle at its insertion on that bone.

mylohyoid and hyoglossus muscle. It is again halted by the submaxillary branch of the lingual nerve, by the submaxillary duct and by the plexus of veins about the duct. The submaxillary branch of the lingual nerve enters the superior pole of the salivary gland, accordingly, traction downward of this gland, along with the areolar and lymph glandular contents of the triangle, pulls the lingual nerve into view (fig 7). The junction point of the nerve branch with the lingual nerve is situated just beneath the lateral border of the mylohyoid muscle near its upper edge. Retraction medialward of the lateral border of the muscle is

removing a fibroma from the main bronchus of the left lung and has seen the patient well seven years after the operation. Another case of fibroma in the main bronchus of the left lung is mentioned by Wessler and Jaches,<sup>20</sup> on roentgen-ray examination this case showed an almost complete atelectasis of the left lung, which after bronchoscopic removal of the tumor cleared up rapidly. Recently Orton<sup>21</sup> reported a bronchoscopic removal of a pedunculated growth from the bronchus of the middle lobe of the right lung, although in this case the histologic opinion was in favor of a malignant tumor, the patient was well four years after the removal of the growth.

We have seen that intrabronchial tumors, while being benign both in their gross appearance and histologically, may lead to rather serious and even grave consequences due to their particular location. An early diagnosis and operative procedure, especially removal by means of bronchoscopy may often prevent extensive pathologic changes and be of great benefit for the patient.

#### SUMMARY

1 A case of a polypoid adenoma of a large bronchus originating from the excretory duct of the bronchial mucous glands is described.

2 The mechanism of the consecutive formation of bronchiectases is discussed.

3 The literature on the subject is reviewed.

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20 Wessler and Jaches. *Clinical Roentgenology of Diseases of the Chest*, Troy, N. Y., 1923, p. 51.

21 Orton, Henry Boylan. *Carcinoma of the Bronchus*, *S. Clin. N. Amer.* 6: 1534, 1927.

usually necessary for exposure. Division of this salivary branch frees the gland and allows the lingual nerve to retract out of danger. The salivary duct is exposed where it enters the base of the tongue by strong traction medially and on the lateral edge of the mylohyoid muscle. Ligations and divisions of the duct and veins release the last hold on the triangle contents. Again caution needs to be observed because the hypoglossal nerve traverses the triangle near the salivary duct and sometimes in the midst of the mass of veins. Before ligation of these veins in this angle, therefore, the nerve should be identified and pushed aside. The dissection is now completed without further interruptions by the final clearing off of the mylohyoid and the hyoglossus muscles down to the posterior belly of the digastric and the styloid muscles and the central

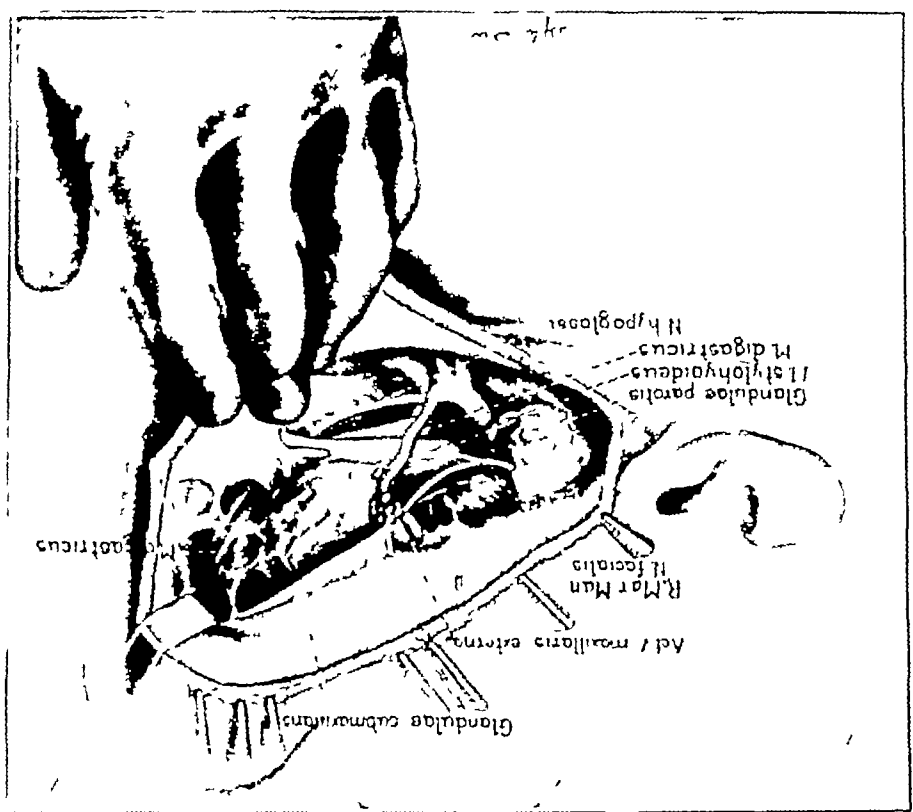


Fig. 6.—Early stage suprathyroid dissection. The facial vessel have been divided the marginal branch of the mandibular (seventh) has been isolated and preserved. The branch of this nerve to the platysma muscle must be divided and is so pictured. The lower pole of the parotid gland has been cleared out and is still intact. The submandibular salivary gland has been freed from the ramus of the jaw by the sharp division of the cervical fascia. The drawing is a representation of the actual dissection in that the submental triangle is not shown and the lower flap has been lifted to show structures below the level of the belly. The submental triangle is cropped in all dissection of the triangle and the lower flap in the pure suprathyroid dissection is never lifted.

location of the facial vessels. The facial veins are cut with the artery while the artery comes up to the level of the mouth with it in view. The arteries toward the level of the mouth are still visible and the facial vessels above that are the same as in the suprathyroid dissection.

# DISSECTIONS OF THE NECK \*

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AND

C LATTIMER CALLANDER, M D

SAN FRANCISCO

Observations of the too frequent indifferent methods and the correspondingly poor results obtained in dissections of the neck in general, invite an attempt to develop an orderly and clearcut technic and a definite understanding of the objects to be attained. The substance of this paper recalls the teaching of the surgical masters of the past and present and, in addition, records the experiences of the authors throughout a decade of surgical operations of the neck.

## CLINICAL INDICATIONS

Dissections of the neck are performed for metastatic carcinomas, primary endotheliomas, localized Hodgkin's disease, intractable tuberculosis and for less frequent conditions, such as lymphosarcoma, carcinoma of the brachial cleft and tumors of the carotid body. Our purpose is to outline a method for the eradication of malignant processes which are primary elsewhere and metastatic in the neck. Primary carcinoma of the lower lip or of the skin of the face below the mouth metastasizes to the glands immediately inferior to the mandible, while carcinoma of the cheek, tongue, tonsil, pharynx, antrum and the lateral portions of the face, metastasize primarily to the lateral regions of the neck. Accordingly, from the surgical metastatic standpoint, the neck is divided into two metastatic regions, i e, the suprahyoid region for carcinoma about the lip and the lateral region of the neck for the other growths enumerated.

## ANATOMIC CONSIDERATIONS

The structures of the neck are so complex and the surgical procedure is so fraught with dangers in the hands of the uninformed, that a thorough anatomic understanding of the neck is of first importance.

*A Suprahyoid Region of the Neck*—The suprahyoid region (fig 1) or, in general, that region between the mandible or lower jaw and the hyoid bone, is divisible into three compartments: a submental compartment and two submaxillary compartments.

The submental division of the suprahyoid region is a triangle bounded laterally by the anterior bellies of the digastric muscles and inferiorly by the hyoid bone. The apex of this isosceles triangle is at the symphysis of the mandible. The anterior wall or covering of the submental

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compartment is made up of the skin and the platysma muscle as well as a sheet of enveloping or deep fascia of the neck. Its posterior wall or floor is composed of the anterior portions of both mylohyoid muscles. The contents of this compartment are simply loose areolar tissue containing lymph glands without important nerves or blood vessels.

Each submaxillary region is also a triangle bounded laterally and below by the two bellies of the digastric muscle and above by the horizontal ramus of the mandible prolonged to the parotid gland. It is covered by the skin and platysma, deep to which is attached a thin layer

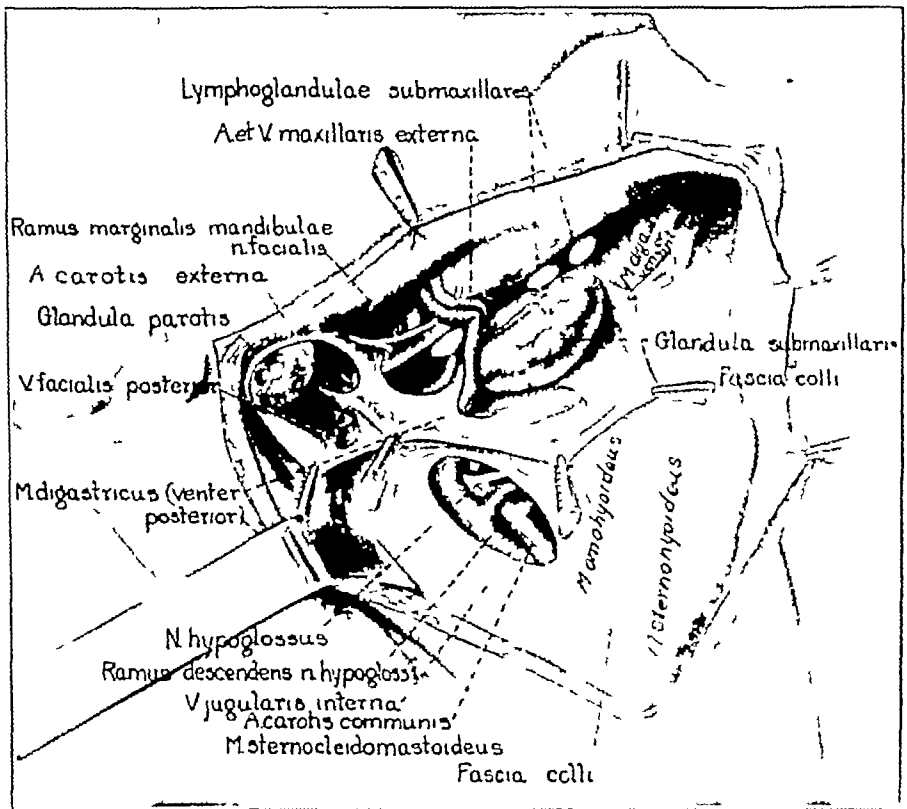


Fig 1—Dissection to show the submaxillary compartment. The skin-platysma flaps expose the enveloping fascia of the neck which has been partly removed to show the contents of the compartment and its investment of the parotid gland together with its relation to the great vessels.

of enveloping aponeurosis continuous with that over the submental triangle. The floor or back wall is composed of the lateral portions of the mylohyoid muscle and the underlying hyoglossus muscle projected laterally to the anterior border of the sternocleidomastoid muscle and the parotid gland.

The contents of the compartment are more important than those of the submental triangle. Each contains a submaxillary salivary gland, the facial vessels, a quantity of loose areolar tissue in which are



embedded several lymph glands, and the more vital structures, namely, the hypoglossal and the lingual nerves. The facial vessels traverse the compartment in its lateral halt and cross over the horizontal ramus of the mandible at a point approximately midway between the angle and the symphysis. The hypoglossal nerve crosses the compartment near its inferior angle where the digastric bellies attach themselves to the hyoid bone. It lies deep to the mylohyoid muscle, and its further course over the hyoglossus is in the cleft between the two muscles. The lingual nerve lies hidden by the ramus of the jaw and courses along and in the sulcus between the under surface of the mandible and the floor of the hyoglossus. Perhaps the largest branch leaves the nerve at the posterior margin of the mylohyoid and immediately enters the substance of the submaxillary gland.

Two important near-related structures which do not actually lie within the compartment are the marginal mandibular branch of the facial nerve and the inferior pole of the parotid salivary gland. The marginal mandibular nerve courses along the outer surface of the mandible, deep to the platysma, but superficial to the enveloping fascia. The inferior pole of the parotid gland is separated from the true compartment by only a thin fascia and is thoroughly exposed in both anatomic and clinical dissections.

*B Lateral Region of the Neck*—Under the heading of the lateral region (figs 2 and 3) of the neck we include all the structures between the trapezius muscle laterally and the ribbon muscles of the thyroid gland mesially, the clavicle inferiorly, and the posterior belly of the digastric muscle with the base of the skull superiorly. This region so described includes, therefore, the rest of the neck, only those structures which are strictly infrahyoid being omitted, i e, the thyroid gland, the laryngo-tracheal tube and the esophagus.

The roof or outer covering of this general region is made up of the skin platysma layer and the enveloping layer of the deep fascia of the neck. The posterior wall or floor is the prevertebral fascia covering the deep muscles of the neck. This space is naturally divided into subcompartments, i e, a region overlaid by the sternocleidomastoid muscle, the sternocleidomastoid or carotid region, and the region posterior to it, the posterior cervical triangle.

(a) *The Carotid or Sternocleidomastoid Region*. This region is an elongated quadrilateral space, bounded by the borders of the sternocleidomastoid muscle, by the mastoid process and the clavicle. In depth, it is considered to extend to the prevertebral fascia.

The sternocleidomastoid muscle, invested by the splitting of the aforementioned enveloping fascia which helps form the roof of the entire neck, may be said to overlie the region at hand. In consideration of this muscle, it should be here noted that the spinal accessory nerve

internal jugular vein (fig 9). In this step the common carotid artery, the vagus nerve and the prevertebral fascia are thoroughly cleaned of loose areolar tissue. The upward dissection may be carried out without fear of mishap or danger to any vital structures because the vagus nerve and common carotid artery are always plainly visible, and the brachial plexus and phrenic nerve are protected by the prevertebral fascia. This fascia, which is never disturbed, is identified as a transparent tough covering closely adherent to the deep muscles of the neck. All branches of the cervical plexus come out through this fascia

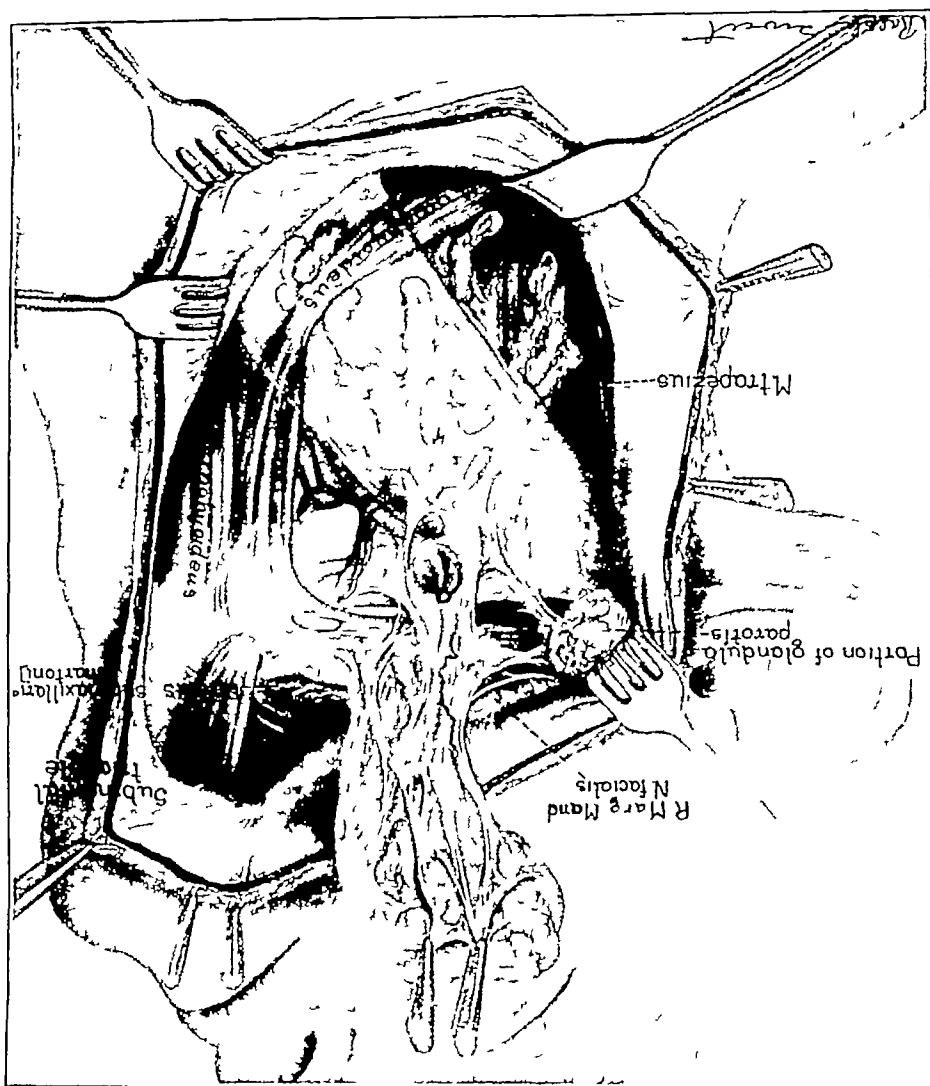


Fig 8—Early stage of the complete dissection of the neck. The suprahyoid dissection has been completed down to the upper margin of the posterior belly of the digastric. The lateral flaps of skin and platysma have been dissected back. The edge of the trapezius marks the lateral limits and the thyroid muscles mark the medial limits of the area to be dissected. The lower limits are defined by dividing the omohyoid and sternocleidomastoid muscles at the level of the crossing of the lower edge of the omohyoid and the lateral edge of the sternocleidomastoid.

enters and leaves it in its superior third. Deep to this root muscle is the omohyoid muscle, an important landmark. The pretracheal fascia, or the anterior prolongation of the enveloping aponeurosis of the neck, forms here a more or less distinct layer, being somewhat cellular and areolar above the omohyoid muscle and resistant to a greater degree including and inferior to it. Its importance lies in the fact that it furnishes a fibrous expansion from the clavicle to the hyoid bone which acts more or less as a protection to the great vessels.

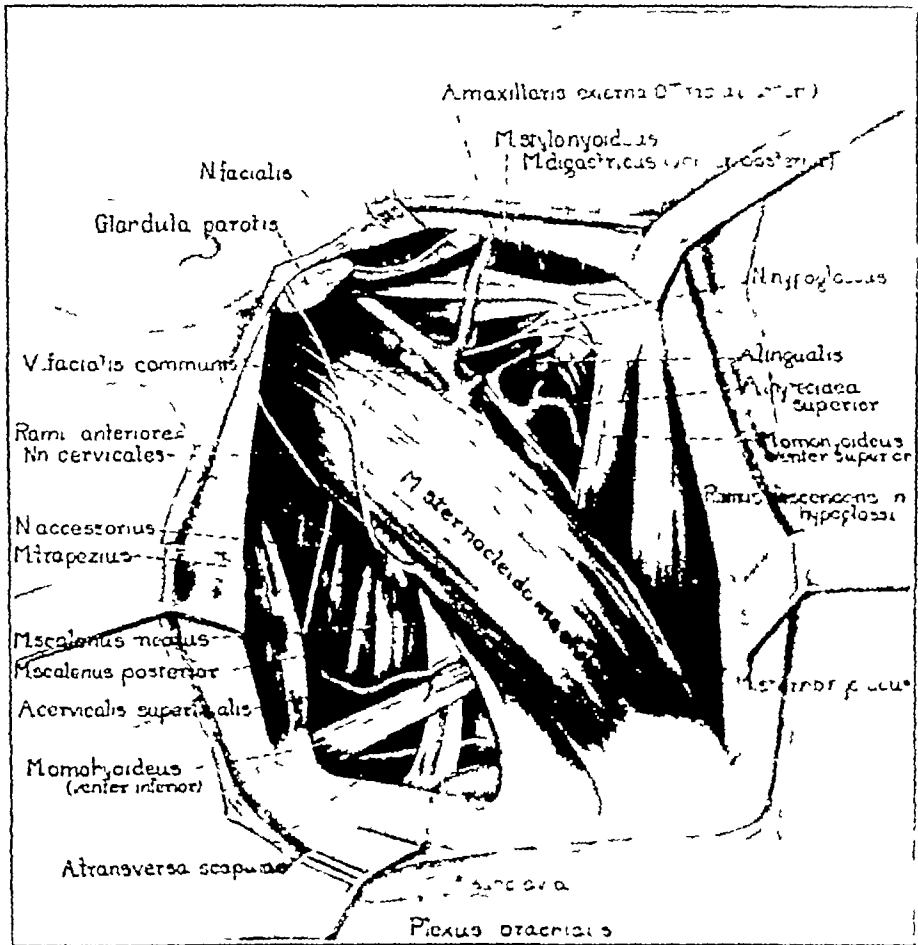
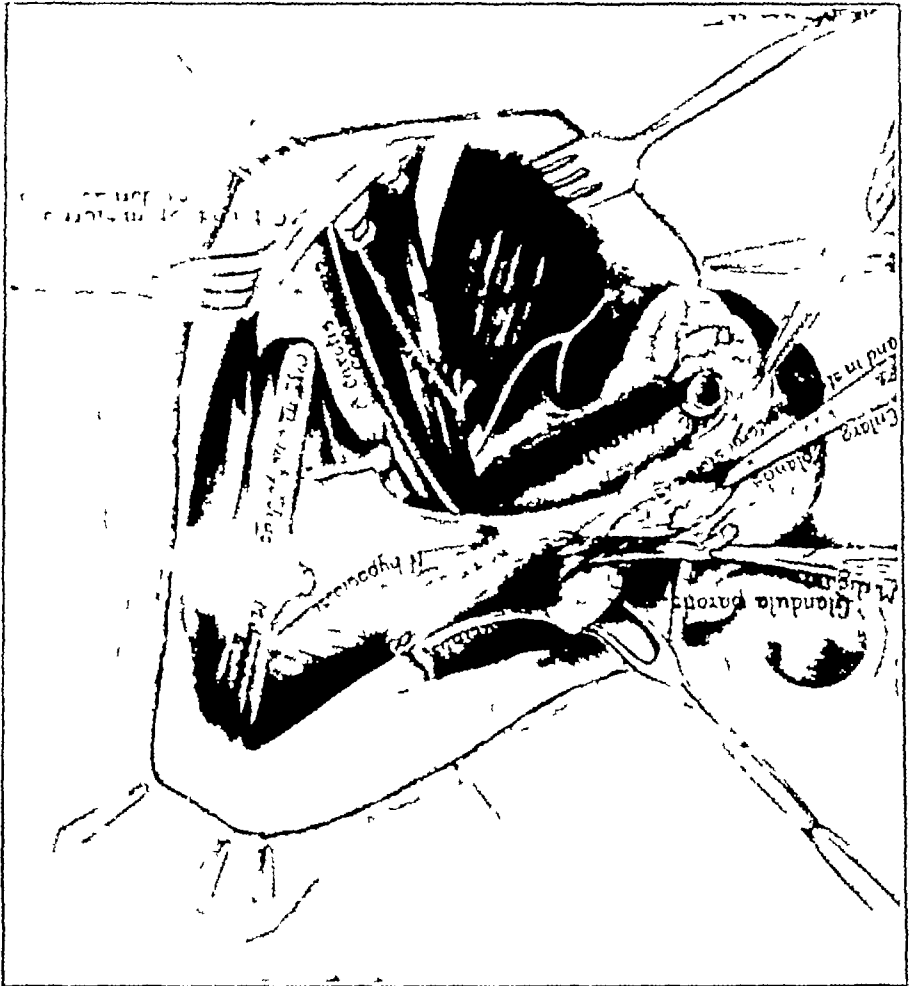


Fig. 2—The lateral region of the neck. The skin platysma flaps are turned back and the enveloping fascia colli is removed. The drawing is designed to show the sternocleidomastoid or carotid and the posterior cervical divisions of the lateral neck with the sternocleidomastoid in situ. Arteries are called to the highly vascular superior extremity of the carotid region.

The contents of this retromuscular compartment include chains of lymph glands embedded in areolar tissue, the great vessels of the neck, and the vagus nerve enclosed within the carotid sheath, the thyro-glandular veins, the hypoglossal nerve and on the left side of the neck the thoracic duct.

**Fig. 9**—Later stage or complete dissection of the feet. The area to be dissected has been outlined below by the division of the sternocleidomastoid omohyoid muscles; the hyarine and division of the external jugular veins and the separation of the tracheal tubes down to the prevertebral column of the neck. The divided structures have been turned up and the process of clearing on the foot, the cartilaginous interdigital spaces stripped of all loose tissue. The tracheas are received in boxes connected by two leaden wires. They are covered with coarse gauze through which air can pass. I have found it is they connect sufficiently to prevent drying. The feet are then put under the preservative liquid.



except the phrenic nerve, and all, with this one exception are divided at their point of emergence, through the fascia. No branches of the carotid artery will be seen until the bifurcation which takes place at about the level of the most prominent part of the "Adam's apple". Usually the first indication that the point of bifurcation has been reached is the finding of a branch, the superior thyroid, apparently coming off from the common carotid vessel. This is due to the fact that the internal carotid lies behind the external at the bifurcation and both are enclosed with a common sheath for one or more centimeters. The bifurcation can always be demonstrated, however, as taking place proximal to this

The lymph glands are largely those of the superior deep cervical chain, and they lie mainly in the loose areolar tissue about the vessels in the upper two thirds of the region. A few glands of this chain extend a little below the junction of the two bellies of the omohyoid muscle, and a few supraclavicular glands of the subclavian or inferior deep cervical chain lie along the upper margin of the clavicle. There is continuity between the superior deep cervical chain of glands and

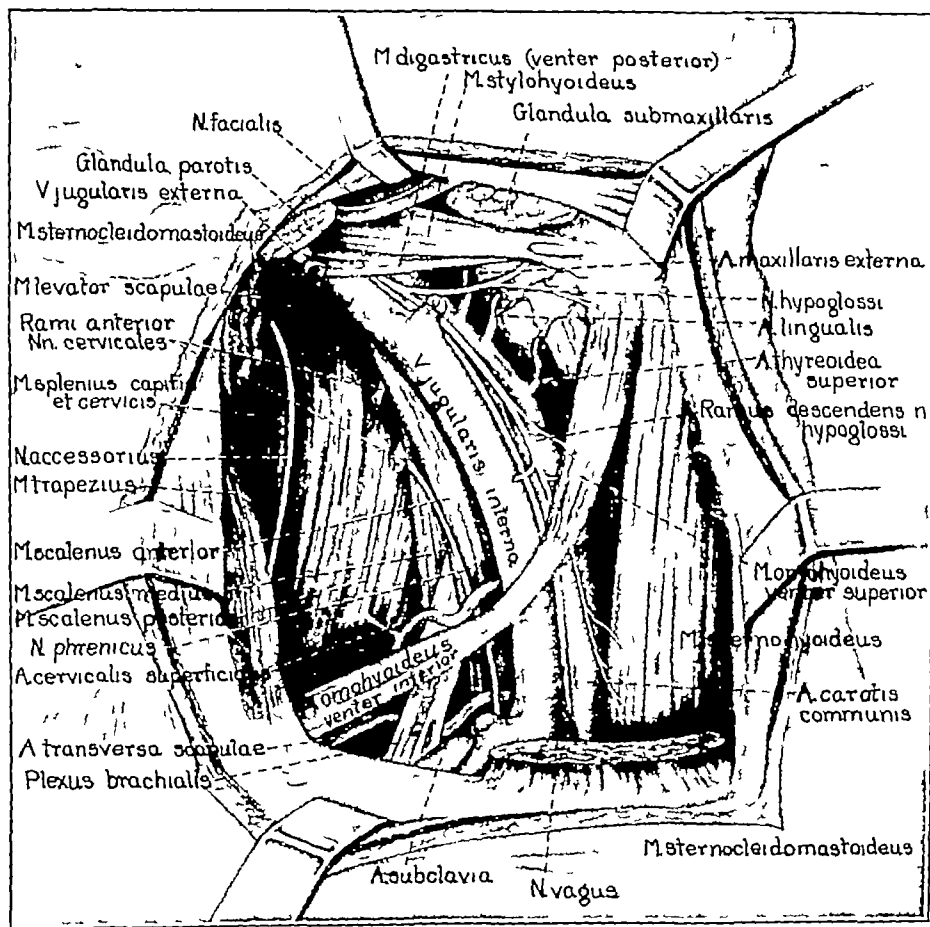


Fig 3—The lateral region of the neck. The sternocleidomastoid muscle is removed to show the structures deep to it and the continuity of the carotid and the posterior cervical divisions of the region.

the submaxillary glands superiorly and with the inferior deep cervical or supraclavicular glands inferiorly.

The contents of the carotid sheath are the common carotid artery, the internal jugular vein and the vagus nerve. The common carotid artery runs from below upward under cover of the mesial border of the sternocleidomastoid muscle as far as the upper margin of the thyroid cartilage, where it bifurcates into its internal and external jugular branches. Over the course of the common carotid artery the internal jugular vein



branch As soon as the identification is clear, a ligature is shipped about the external carotid artery and tied just proximal to the superior hyoid branch, thus insuring the ligature from slipping off the end. Both vessels are then divided after clamping or ligating the distal stumps. The upward dissection should now proceed smoothly providing the medial area is dissected first until the tendinous portions of the stylohyoid and digastricus muscles and the hypoglossal nerve are exposed. Great care must be taken to isolate the hypoglossal nerve which makes a loop below the level of the posterior belly of the digastricus muscles, extending frequently 2 cm below the lower border at the central portion of the belly and crossing under the muscle in its tendinous portion at the hyoid cornu (fig 9). The nerve is easily identified rather deep on the floor of the neck, if sought for beneath the hyoid cornu. Dissection may now continue upward and lateralward following the stylohyoid muscle in the direction of the styloid process, and is usually carried through to the base of the skull. Frequently, however, it is not possible to proceed further than the isolation of the hypoglossal nerve because of metastatic masses which prevent the proper turning up of the contents of the neck and the complete exposure of the floor of the neck at the base of the skull. Working in this corner without sufficient room may result in the nicking of the internal jugular vein on its under surface with an obscuring of the field and discoloring of the tissues from flooding of the area with venous blood.

The last step takes place at the upper lateral angle, and has to do with the cutting away of the sternocleidomastoid muscle from the mastoid process, with the taking away of the lower pole of the parotid gland, and the ligation of the internal jugular vein at the skull (fig 10). The lower part of the parotid gland (approximately from 1 to 2 cm) must be taken because some of the lymph glands at the upper end of the deep cervical chain lie embedded within this structure. In cutting through the parotid, innumerable veins, many of considerable size, must be divided, and progress here usually is slow. On completing this dissection the most difficult task still remains, i.e., the isolation and ligation of the internal jugular vein and the identification and preservation of the vagus, the hypoglossal and the spinal accessory nerves. These nerves lie close to the floor of the neck, also close to the vein, so that mass ligature is not possible. It is well to approach the vein from one side and then the other, leaving the direct working down on the vessel as the last step. The complete removal of the internal jugular vein is required because of two facts, namely, the intimate relationship of the lymphatic vessels and glands with the sheath of the vein all along its course and the location of the highest gland in the deep cervical chain against the vein at the skull (fig 4). The spinal accessory nerve too often must be sacrificed in the radical dissection for carcinoma, because in its passage through the sternocleidomastoid muscle it frequently becomes involved in a tumor mass and cannot be separated without danger of leaving carcinomatous tissue behind.

With the completion of the dissection, the floor of the neck is clear, that is, the prevertebral fascia has been cleaned of all loose areolar tissue and is everywhere intact. The vagus, hypoglossal, and frequently, the spinal accessory cranial nerves may be seen lying on the floor of the neck, the vagus lying against the lateral wall of the common carotid artery, the hypoglossal looping down beneath the posterior belly of the digastricus muscle and disappearing underneath its end at the hyoid bone, and the spinal accessory passing obliquely downward and backward to disappear beneath the edge of the trapezius near the lower angle of the wound at the lateral corner. The common and internal carotid arteries are

lies external to it. Superior to its bifurcation however the internal carotid artery runs posterior to the internal jugular vein in its course to the base of the skull. There are no branches to the internal or the common carotid artery in the neck while the external carotid in our region gives off the superior thyroid, lingual and external maxillary branches. The superior thyroid artery leaves the parent trunk about 1 cm. from the bifurcation and the lingual and facial vessels at a more distant point.

The internal jugular vein begins at the base of the skull deep and anterior to the mastoid process of the temporal bone and deep to the external auditory meatus. It passes downward and forward beneath the sternocleidomastoid muscle and lateral to the common carotid artery.

The vagus nerve leaves the skull beside the internal jugular vein and courses mesial to this vein as far as the common carotid artery, where it lies between and behind these structures in the carotid sheath until its entrance into the mediastinum.

The hypoglossal nerve emerges from the base of the skull near the two foregoing structures and courses with them for a short distance to a point on a level with the hyoid bone, so that it runs forward and upward and crosses between the posterior belly of the digastric muscle and the hyoglossus muscle to the submaxillary compartment as has been already described. The spinal accessory nerve leaves the skull soon to traverse the superior third of the sternocleidomastoid muscle and to be distributed through the posterior compartment to the trapezius muscle.

The veins from the face, the tongue and the thyroid gland enter into a more or less common trunk, the thyrolingual-facial trunk, which lies in the superior portion of the region and communicates with the internal and external jugular vein.

The anterior branches of the cervical plexus with the exception of the phrenic nerve, pierce the prevertebral fascia to emerge through the posterior triangle at about the posterior margin of the sternocleidomastoid muscle. There are the great auricular and the lesser occipital nerves and, in general, the nerves that supply the scapula. The phrenic nerve lies on the anterior scalene muscle deep to the prevertebral fascia or the floor of the region.

The parotid gland while encased in a compartment of its own is nevertheless in intimate relation not only with the submaxillary region but with the superior portion of the sternocleidomastoid region. Its importance in this discussion lies in the fact that some of the lymph glands of the superior deep cervical chain are in close contact with its interior pole.

Within the region on the left side the thoracic duct enters this compartment from the chest and empties into the junction of the left subclavian and the left internal jugular vein. The cords of the brachio-

also seen traversing the floor of the neck from the clavicle to the base of the skull. A row of stumps of branches of the cervical plexus penetrating the pre-tracheal fascia, that is, the floor of the neck, lies just lateral to the artery. The phrenic nerve may be seen coming out from behind the lateral edge of the scalenus anticus muscle together with the nerve to the lowest stump, but instead of piercing the fascia and suffering division with the other branches of the cervical plexus, it courses down along the anterior surface of the muscle belly beneath the pre-tracheal fascia and disappears behind the clavicle into the chest. The brachial plexus also is seen beneath the same fascia at the extreme lower and

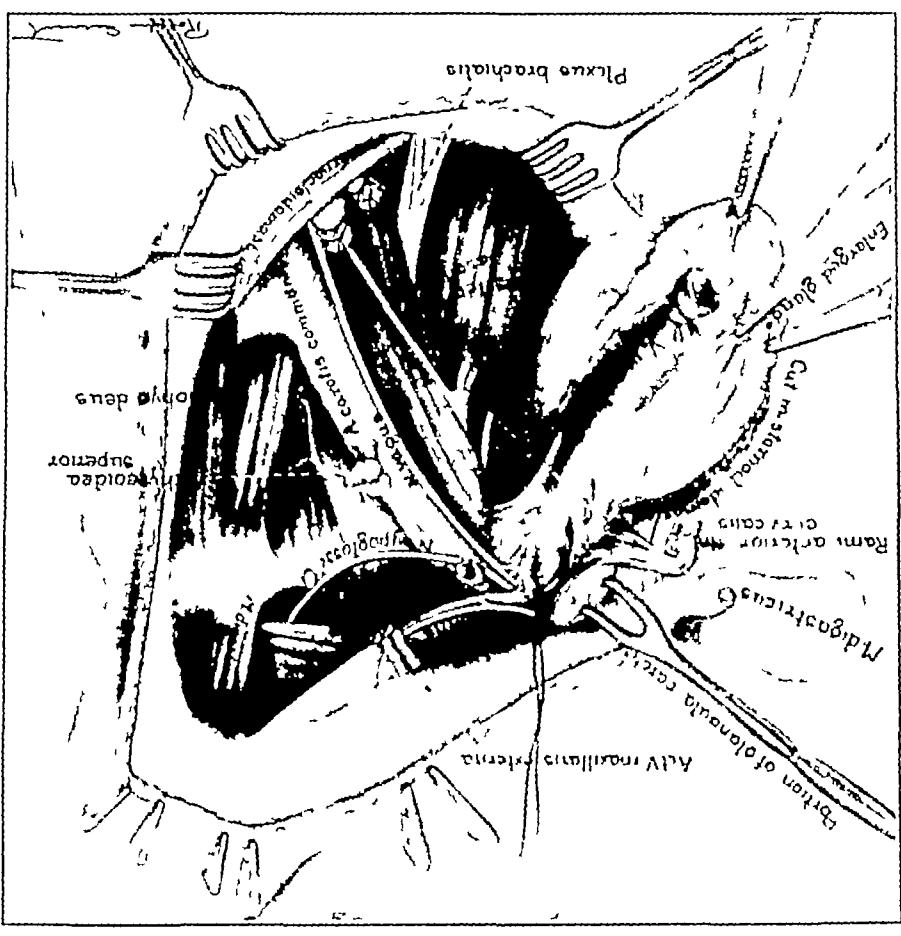


Fig 10—Last stages of complete dissection of the neck. The external carotid artery has been doubly ligated and divided. The hypoglossal nerve has been stripped and carefully preserved. The lower pole of the parotid gland has been taken away and the jugular vein has been ligated at the base of the skull. This cannot be shown accurately because the point of ligation would be too high up under the parotid and angle of the jaw to be visible from this angle. The vagus, hypoglossal and accessory nerves lie close to the vein at the site of ligation and must be identified before the ligature is placed.

medial angle alongside and lateral to the common carotid artery. The remaining mass of loose areolar tissue surrounding the subclavian vein and covering the apex of the lung, pumps up and down with respiration.

In sixty-three cases (68 per cent) the thyroid gland was not involved diffusely, but the morbid process (hypertrophy and hyperplasia) was confined to certain specific regions. The histologic manifestations of hypertrophy and hyperplasia were accompanied by those of involution. This was to be expected because the clinical condition, hyperthyroidism, had been present in these cases for a number of years. Thus the diphasic cycle of the disease process had been completed many times in certain localized areas of those glands. It would, therefore, not be possible to have the histologic changes characteristic of the active phases of the disease, the hypertrophy and hyperplasia, without those accompanying the less active phase, namely, the involutional changes. The size of the nodules varied from small ones to those as large as a man's fist. The larger ones were found more frequently in older people in whom the duration of the disease had been longer and in these cases the capsules were more clearly defined, probably as the result of a greater degree of pressure atrophy exerted over a longer period of time. These cases, clinically and pathologically, seemed to represent a chronic manifestation of the same disease process which appears more acute in typical exophthalmic goiter. It has become firmly fixed in the minds of some observers that a nodule of considerable size with a capsule around it is necessarily a neoplasm and, therefore, an adenoma. That this idea is incorrect would seem to be proved by this study. Nodules of all sizes may develop as a result of involution of a previously diffuse hyperplasia of the thyroid or because localized specific regions of the gland become the site of the disease process while the intervening parenchyma retains the appearance of normal thyroid tissue. The size and encapsulation of the nodules or tumefactions in either group is in direct proportion to the length of the disease process and the age of the patient, or the direct ratio of the frequency of the completion of the disease cycles. This study, then, shows that in 52 per cent of our cases of nodular goiter with hyperthyroidism, the nodular elements did not represent true benign neoplasms or adenomas. Careful examination of these nodules revealed the fact that the pattern suggests the microscopic appearance of hypertrophy and hyperplasia rather than that of in recognizable neoplasms of the thyroid gland.

It would seem that the morbid processes may involve only certain regions of the thyroid not only in the more active states but also in the localized areas of hypertrophy and hyperplasia. In fact, the active and inactive states as shown by the delimited areas of hypertrophy and hyperplasia, the parenchyma between the nodules, is apparently being normal.

In 34 per cent of the cases in this study the nodules of the thyroid was composed of involutional changes. In 52 per cent of the cases the goiter had resulted from a regional involvement of the thyroid.

the same pathologic process, so that it would appear that the formation of a nodular goiter must be considered as one of the final stages or pathologic sequelae of the clinical entity, hyperthyroidism. In a relatively small percentage (only 8 per cent in our series) was the nodular element due to a true benign neoplasm.

The older patients with hyperthyroidism associated with a nodular goiter are those who have survived the disease long enough for the nodules to develop in the thyroid glands. The fact that they are better operative risks and are less apt to have severe postoperative reactions than the younger patients with a more acute clinical picture and a diffuse hypertrophy and hyperplasia of the thyroid gland, would tend to bear out this statement.

In the last few years, references to "toxic adenoma" and "hyperfunctioning adenomatous goiter" have frequently appeared in American medical literature. These terms are obviously incorrect and misleading. In the small percentage of cases in which true benign neoplasms are associated with hyperthyroidism the histologic manifestations of hyperactivity of the parenchyma have been demonstrated throughout the gland as a whole, so that the neoplasm should be regarded merely as a coincidental pathologic lesion.

There is no proof that the secretion of a benign tumor can affect the organism as a whole or that it can give rise to toxic manifestations.

At present it is impossible to make a differential clinical diagnosis between a true benign neoplasm, an involutonal nodule and a tumor resulting from a localized area of hypertrophy and hyperplasia with involution in a patient with hyperthyroidism. Nodular goiter with or without hyperthyroidism and diffuse goiter with or without hyperthyroidism would seem to be a more accurate and an equally efficacious clinical distinction.

## COMMENT

Modifications of the combined suprahyoid and lateral dissections of the neck may be allowed in tuberculosis and Hodgkin's disease. In such cases the sternocleidomastoid muscle may be preserved, the cervical nerves are spared, and the internal jugular vein is taken only as a matter of convenience. In metastatic carcinoma, in carcinoma of the branchial cleft and in endothelioma of the neck the procedure is never more limited than that outlined in the foregoing description of the combined operation. Sometimes additional structures must be removed, occasionally the hypoglossal nerve and the digastricus and stylohyoid muscles must be dissected out because of their involvement within a large carcinomatous mass. Even the vagus nerve sometimes must be sacrificed. Removal of less than the whole of the deep cervical chain in metastatic carcinoma involving these groups of glands is just as inadequate as a simple amputation without axillary dissection for carcinoma of the breast.

Simple suprahyoid dissection is an absolute safeguard in cancer of the lip. It should be employed early in the course of the disease before gross involvement of glands has taken place, and should not be delayed until there is little doubt regarding the malignant nature of the swelling or enlargement of the glands beneath the chin. Microscopic examination of the glands may fail to reveal metastatic carcinoma in a surprising number of instances, but statistical studies show that in a high percentage of the cases in which dissection of the neck is not employed the patients return to the physician later on account of metastases. This is especially true of the cases which show involvement of the muscle of the lip or in which there is a slight degree of differentiation of cells. Dissection of the neck in the suprahyoid region is not mutilating, no vital structures are in danger, and the procedure is simple and can be accomplished by one with a limited surgical experience, on the other hand, the results from the standpoint of protection are absolute.

The combined suprahyoid and lateral dissection for metastatic carcinoma in the deep cervical chains is almost as satisfactory even in the presence of gross involvement of these glands, and in the majority of instances gives a complete and permanent block to the spread of the disease by metastases. While it is true that cures are relatively few in carcinoma of the tongue or the pharynx, it is the inability to get rid of the primary focus and the infiltration of the floor of the mouth or pharynx and not the inability to control metastases that accounts for the failure. The later dissection, while not as simple as the suprahyoid, can be easily mastered, and is not a formidable procedure for surgeons who are skilled in handling tissues, even though they have had little experience in operations on the neck. Even in this extensive procedure, mutilation is negligible. The bilateral combined operation is seldom employed,

grams made of the leg and foot after injection of sodium iodide into the femoral artery indicated a good arterial supply to the leg. The medium stayed in the arteries for a considerable length of time, none of it being in the arteries after an hour, however, except probably a small amount which stuck to the wall. On February 12, the skin showed a mottling appearance up to the knee and this mottling was extending medially to the perineum. On February 17, the leg had increased markedly in size and had apparently lost all sensation. A definite line of demarcation was not present. The odor was typically

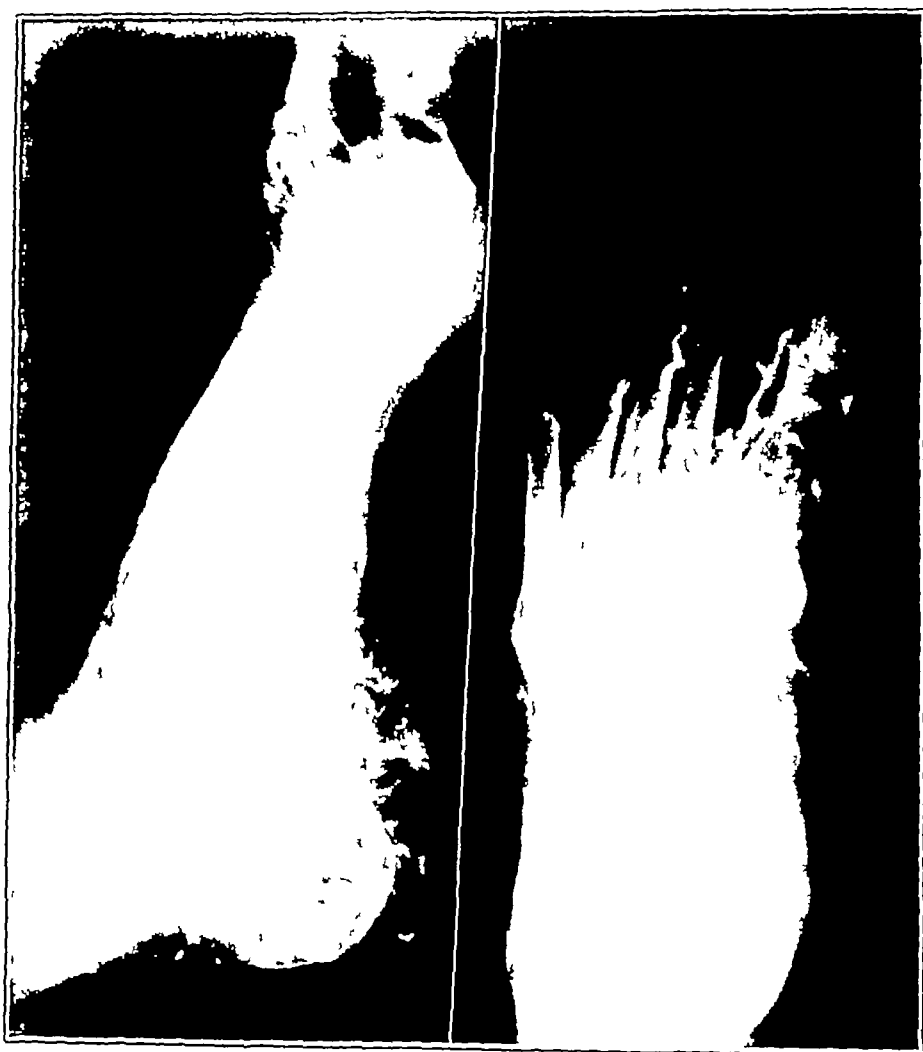


Fig 6 (case 6)—Arterial tree in the foot showing arterioles blocked by disease in a case of senile gangrene. The solution is seen being retained in the arterioles and capillaries.

gangrenous. On February 20, the lower half of the thigh in front and the thigh to the buttocks posteriorly showed moist gangrene. The patient was unconscious. The blood pressure was decreased, and catheterization was necessary. The patient recovered ability to void, but showed no particular improvement. He died on March 1.

In this case also the results were unfavorable, and it was again demonstrated that sodium iodide is dangerous if there is sufficient obstruction to cause its

but may be performed without fear of serious consequences. It is wise to allow sufficient time between the two operations for the establishment of collateral circulation.

Apropos of recent discussions concerning the anesthetic to be employed in complete dissection of the neck, it has been our experience that the most satisfactory anesthetic is light ether, that is, a minimum of ether and a maximum of air. Local anesthesia with procaine hydrochloride, nitrous oxide and oxygen, ether and chloroform have been employed. Ether is preferred because postoperative pneumonia and mortality have been negligible and because the patients have been more comfortable following this type of general anesthetic. With local anesthesia the discomfort of lying on the table throughout the long period required for a painstaking operation of this sort is a point to be weighed. There is more oozing under nitrous oxide because of the unavoidable cyanosis, be it ever so slight, in addition, the method of administration is more difficult because of the proximity of the operative field to the face. Obstetric chloroform would be the ideal anesthetic in the hands of an anesthetist absolutely familiar with the drug.

Ether should be administered intrapharyngeally with some machine adapted to furnish air under positive pressure. The intratracheal method of administering ether anesthesia is to be avoided because of the high mortality when this method is used because of the difficulty of administration, and because it is not an improvement on the intrapharyngeal method.



attention in the vessels for an unduly long time. In arteriosclerotic gangrene, as previously mentioned, the capillaries and arterioles are markedly narrowed, and unquestionably in this type of case, the injection is not to be used.

#### SUMMARY

1 Roentgenologic examination after intra-arterial injection of sodium iodide accurately reveals the condition of the blood vessels. Such injection is apparently harmless when there is good capillary circulation and a free return of blood into the general circulation. The method is apparently safe.

2 In aneurysms of the extremities, both arterial and arteriovenous, valuable information is gained in regard to the blood vessels entering and leaving the aneurysms and the collateral circulation, which may be of great assistance in determining the method of treatment.

3 In spontaneous gangrene resulting from venous or arterial obstruction, the method is not safe and probably should not be used. It is contraindicated in moist gangrene with venous obstruction, and also in arteriosclerosis because of the narrowing in the arterioles and capillaries. In thrombo-angitis obliterans, the capillaries are usually much more normal, and there is better collateral circulation, therefore, in this condition, the method should not be harmful.

# USE OF INTRA-ARTERIAL INJECTIONS OF SODIUM IODIDE IN DETERMINING CONDITION OF CIRCULATION IN THE EXTREMITIES

REPORT OF CASES \*

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Impairment of the circulation in the extremities due to diseased blood vessels, which results in gangrene and the symptoms accompanying it, is of ever growing importance. The conditions responsible for these failures of circulation may be considered as aneurysms of various types and obstructions to the arteries and veins. The acute obstructions may be due to emboli or thrombi obstructing important vessels, the result of which may be gangrene if either the arterial or venous blocking is sufficiently complete. The more chronic types of gangrene are the result of arterial disease, and clinically and pathologically, these are recognized as (1) the arteriosclerotic type which embraces senile and diabetic gangrene, (2) thrombo-angitis obliterans (Buerger's disease) and (3) arterial spasm (Raynaud's disease).

Each of these three types of disease of the blood vessels differs distinctly in its pathologic changes. In the arteriosclerotic type, the entire arterial system is involved, the capillaries and arterioles being seriously involved, and the development of a compensatory collateral circulation is hardly possible. In thrombo-angitis obliterans, the capillaries and arterioles are not affected to a corresponding extent, and the development or improvement in the collateral circulation is possible. In Raynaud's disease, an arterial spasm exists rather than permanent changes in the blood vessels. This knowledge should be kept in mind, and efforts at treatment of patients with gangrene or impending gangrene of the extremities should be guided accordingly.

In the arteriosclerotic type, in spite of many reports to the contrary, arterial sympathectomy is probably not indicated. If methods other than palliative measures or amputation are used, obstruction of the venous return of the blood from the extremity should at least theoretically be resorted to by partially blocking the femoral vein and thereby utilizing to the fullest extent the diminished amount of blood which passes through the small arteries. It may be that in some cases the good results which have followed arterial sympathectomy or the injecting of alcohol around the artery for the same purpose, as practiced by

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\* Read before the Southern Surgical Association, Augusta, Ga., December, 1927

# STUDIES IN INTESTINAL OBSTRUCTION

## III SIMPLE OBSTRUCTION A STUDY OF THE CAUSE OF DEATH IN MECHANICAL OBSTRUCTION OF THE UPPER

### PART OF THE INTESTINE \*

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AND

STANLEY S CHUNN, M.B.

MINNEAPOLIS

There are two fairly distinct types of intestinal obstruction, clinically as well as experimentally, in one the continuity of the intestinal canal has been interrupted, in the other gross evidence of damage to the obstructed segment exists in addition to a break in the continuity of the tract. These forms have aptly been described as simple and strangulation obstruction.<sup>1</sup>

Early clinicians and investigators thought that in simple occlusion of the bowel, the wall became permeable to bacteria in the intestine, and peritonitis and bacterial invasion of the organism brought about a lethal outcome.<sup>2</sup> Such a contention has been set aside by subsequent investigation, as well as by the frequent opening of the abdomen, under aseptic conditions of both patients and dogs with obstruction

Amussat<sup>3</sup> is generally looked on as being the originator of the intoxication theory for the explanation of symptoms and death in intestinal obstruction. This view, which today has most investigators and clinicians as its adherents, accounts for the lethal outcome in the formation and absorption of potent toxins above the point of obstruction. Braun and Borstau,<sup>4</sup> unable to verify the presence of a toxic body in the obstructed intestine that is not present normally, ascribed death to splanchnic paresis and shock. Hartwell and Hoguet<sup>5</sup> inclined

\* From the Department of Surgery of the University of Minnesota

\* Presented before the Minnesota Pathological Society

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Sampson Handley,<sup>1</sup> in senile gangrene, have been due to the partial obstruction of the femoral vein by the swelling of the surrounding tissue following the operative procedures

In the second type of gangrene (Buerger's disease), there is a possibility of an improvement of the collateral circulation, and with the lower extremity involved, the ligation of the femoral artery as practiced by Dr Dean Lewis<sup>2</sup> would possibly be the treatment of choice

The uniformity of the arterial channels and their collateral circulation can usually be relied on to guide one to the most favorable site for amputation. But because one cannot tell the exact condition of the vessels, one may sacrifice an unnecessary length of leg, or again one may amputate at too low a level, so that the condition for which amputation was performed would not be relieved. In order to determine more definitely the location of the vascular obstruction, many methods have been suggested, no one of which has been entirely satisfactory. The Moskowitz method is well known, and the test depends on the alteration of the color of the skin which results from the alternate application and removal of a tourniquet. But this method is often inadequate and unreliable.

The change in the temperature of the foot or toe produced by the application and removal of a tourniquet, as recommended by Brooks<sup>3</sup> following some excellent observations, is more promising and with development may be of great value. The apparatus consists of a thermocouple mounted in a hypodermic needle and a galvanometer. It permits of accurate measurements of the temperature of the foot and records accurately rapid change in temperature. The tourniquet is applied for ten minutes, and the temperature of the tissues of the extremity falls to room temperature. It was found that with the removal of the tourniquet the temperature in the tissues of the normal extremity rapidly rose to normal. On the other hand, in the tissues of an extremity in which there was impairment of the arterial blood supply, the release of the tourniquet was not followed by a prompt rise in temperature.

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to the belief that dehydration in itself is the most important factor Hausler and Foster<sup>6</sup> stated that death in cases of simple occlusion of the bowel can be accounted for on the basis of starvation alone

Since Hartwell and Hogue<sup>8</sup> first made known the efficacy of saline in prolonging the life of the animal in which an obstruction had been established experimentally, this observation has been corroborated by a large number of investigators and clinicians.<sup>7</sup> Extensive experimentation by Haden and Orr relative to the protection that sodium chloride solution afforded the animal<sup>8</sup> with intestinal obstruction would indicate that the virtue of the saline lay in the drug per se. They were unable to obtain the same beneficial effect from other drugs containing either the sodium or the chloride radical alone. They believed that sodium chloride combines with the toxic bodies responsible for the fatal issue in intestinal obstruction, rendering them inert.

In a previous study,<sup>9</sup> by experiments on animals we were unable to ascertain the presence of toxic bodies in the intestine with simple obstruction not found in the normal intestine. The intestinal contents of dogs with an obstructed intestine to which salt solution had been administered were also toxic on injection. This would indicate that unusual toxins, if present, were not rendered innocuous within the bowel.

In another study<sup>10</sup> it was found that the intestine, with interruption of its continuity, was not abnormally permeable to histamine. In this investigation we have been concerned only with simple obstruction with particular reference to the evidence that abnormal absorption from the obstructed bowel is responsible for the death of such an animal.

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 9 Wangensteen, O. H., and Chunn, S. S. Studies in Intestinal Obstruction A Comparison of the Toxicity of Normal and Obstructed Intestinal Content, Arch Surg, to be published  
 10 Wangensteen, O. H., and Loucks, M. Studies in Intestinal Obstruction, II The Absorption of Histamine from the Obstructed Bowel, Arch Surg, to be published

Still another method of determining the condition of the circulation in the extremities is by the injection of sodium iodide into the arteries and by roentgenologic examination. Brooks is also credited with making and publishing important experimental and clinical observations in the use of this method. He recommends the exposure of the femoral vein and artery in Scarpa's triangle, and with the vein and artery clamped above, 10 cc of 100 per cent sodium iodide is injected into the artery with a syringe and needle and a roentgen-ray exposure is rapidly made on a sensitive plate. The pain is severe, and a short gas anesthesia is required. I have made use of this method in six patients since the publication of Brooks' work. The technic employed has been slightly different in that a light spinal anesthesia was used in four patients, this seemed to have the advantage of securing the cooperation of the patient. It was also not found necessary to expose the vessels by an incision, but the solution was easily injected with a needle through the skin, while an assistant exerted pressure over the artery and vein just below the inguinal ligament. The results of my experiences cause me to both recommend and to condemn the method. It is because of the unfavorable results, as much as the favorable, that I am prompted to make a record of my observations.

Three of the six cases that are reported, occurred in patients with aneurysms—one of the popliteal artery, one an arteriovenous aneurysm of the femorals and one an aneurysm of the first part of the brachial artery. The results in these three cases were satisfactory, and the information gained was invaluable. The other three cases occurred in patients with gangrene of the toes or feet. Two were of the senile or arteriosclerotic type, and the other was a moist gangrene due to venous thrombosis of the femoral vein associated with sepsis. In these cases, the results were decidedly unfavorable. While the arterial tree showed perfectly and the condition of the circulation was revealed thoroughly, the damage to the already diseased and narrowed arterioles and capillaries from the sodium iodide was evident, in two instances, the gangrene spread rapidly, necessitating a high amputation in one, while death followed in the other.

#### REPORT OF CASES

CASE 1—E. S., a colored man, aged 30, entered the hospital on Nov. 8, 1922, because of chronic ulcers of the leg which would not heal. Physical examination at this time revealed the classic signs of an aneurysmal ligament.

The diagnosis was chronic syphilitic ulcers of the left leg and arteriovenous aneurysm of the left femoral artery and vein. Healing of the ulcers occurred following the application of dressings and antisyphilitic treatment. The patient left the hospital on December 11, with the ulcers improved, but the condition of the aneurysm was the same. The patient reentered the hospital on Jan. 16, 1923, with ulcers of the left ankle and poor circulation in the left leg. Results of physical examination at this time were essentially the same as those on the

As considerable experimentation has been done in this field, a number of the experiments reported in this study have been performed by other investigators. In order to be able to interpret the results of such experi-

*Data on Dogs in Experimental Intestinal Obstruction*

Dog	Nature of Procedure	Operation	Day After	Blood			Urine and Vomitus	
				Mg per 100 Cc.	Chlorides	Amount	Nonprotein	Protein
82	Duodenal obstruction of the severed		0	11.80	640	125	0.80	0.80
Weight, 40 pounds (18.1 Kg.)	Intestine, 12/22/26		1	26.60	430	1,260	8.67	8.67
			2	19.20	430	316	4.41	4.41
			3	40.18	430	650	5.06	5.06
			4	38.73	360	160	2.66	2.66
			5	41.62	340	600	5.32	5.32
			6	69.20	310	620	5.04	5.04
			7	83.10	320	640	4.10	4.10
Died 12/29/27, weight at death, 32 pounds (14.5 Kg.)								
83	Duodenal obstruction of the severed		0	10.26	490	90	1.10	1.10
Weight, 29 pounds (13.2 Kg.)	Intestine, 12/22/26, given 400 cc 2% saline subcutaneously once daily		1	19.13	460	365	4.06	4.06
			2	21.46	460	1,500	6.44	6.44
			3	18.66	660	1,010	7.98	7.98
			4	16.86	740	2,200	6.67	6.67
			5	16.80	660	2,225	7.62	7.62
			6	20.53	620	2,700	5.23	5.23
			7	16.66	600	870	6.03	6.03
			8	27.30	430	1,850	5.68	5.68
			9	18.26	410	1,025	4.37	4.37
			10	17.87	390	1,300	3.95	3.95
			11	14	470	1,625	6.40	6.40
			12	16.30	620	740	3.33	3.33
			13	14.47	410	110	1.54	1.54
			14	16.64	400	160	3.20	3.20
			15	16.88	310	265	2.30	2.30
			16	18.20	310	120	2.40	2.40
			17	16.40	310	60	1.20	1.20
			18			100	2.40	2.40
Dog died 1/10/27								
94	Duodenal obstruction of the severed		0	14	530	2,500	4.42	4.42
Weight, intestine and gastroenterostomy, 39 pounds (17.7 Kg.)	Intestine and gastroenterostomy, 1/6/27 no saline given		1	14.47	400	2,000	3.38	3.38
			2	28.36	350	2,000	5.27	5.27
			3	26.20	250	2,000	5.27	5.27
			4	18.20	310	440	4.52	4.52
			5	60.93	260	1,000	6.30	6.30
			6	84.46	260	450	4.95	4.95
			7	119.06	250	870	7.40	7.40
Died, weight, 29 pounds			8			1,750	6.70	6.70
116	Duodenal obstruction and gastro		0	9	600	125	1.20	1.20
Weight, enterostomy, 2/7/27, saline given 400 cc 2% subcutaneously, 400 cc 2% once daily			1	14	440	460	0.60	0.60
			2	16.08	430	2,700	8.76	8.76
			3	15.78	360	8,200	8.76	8.76
			4	14.32	610	1,075	3.70	3.70
			5	17.75	250	1,400	4.66	4.66
			6	9	430	630	3.40	3.40
			7	18.60	410	600	3.87	3.87
			8	16.60	410	600	3.87	3.87
			9	16.86	440	600	2.43	2.43
			10	17.40	430	600	2.60	2.60
			11	23.20	460	300	1.06	1.06
			12	14	420	250	1.76	1.76
1/7/27, dog in satisfactory condition, weight 34 pounds (15.4 Kg.), vomits occasionally								

\* In these experiments the urine and vomitus were collected together. The dogs were allowed to drink water.

ments with any judgment, we felt that it was necessary to make our own observations. Since the results of a number of the experiments to be cited are fairly well known and established, the experimental procedures will not be listed in detail.

first admission. Roentgen-ray examination of the arterial tree showed the connection of the varix to be a wide communication between the artery and vein. Operation confirmed the diagnosis of an aneurysmal varix, and the afferent and efferent arteries were ligated and divided. The patient recovered from the operation and the ulcers about the ankles healed rapidly. When the patient was dismissed from the hospital on March 16 the circulation in the leg and foot was fairly good. A low localized bruit could still be heard over the middle third of the thigh. The patient reentered the hospital on June 30 because of fracture of the base of the skull. He recovered completely from this condition. On July 11, the femoral artery was again injected with 10 cc of 100 per cent sodium iodide, and a roentgenogram was made which showed the ligated ends of the artery, the profunda femoris and a large number of small collaterals connecting the two portions of the artery. The patient was discharged from the hospital on July 25, is improved.

The information gained by the arterial injection previous to the operation was of value in that it showed the inadvisability of attempting to separate the artery and vein and suture the separate openings, which method probably would otherwise have been attempted.

CASE 2—D. P., a colored man, aged 46, was admitted to the hospital on July 19, 1924, his chief trouble being granuloma inguinale which had produced a urethral fistula. He had also complained of pain in the left leg which caused him to limp or to have difficulty in walking because of a "knot" at the posterior part of the joint of the knee. A diagnosis of popliteal aneurysm was made. Twenty cubic centimeters of 100 per cent sodium iodide was injected into the femoral artery, and a roentgenogram was made. This showed an enormously dilated femoral artery of the left leg with a popliteal aneurysm with partly calcified walls. The condition of the entire femoral artery as shown by injection of iodine indicated that operative treatment was not advisable.

Without the roentgen-ray observations I think unquestionably that an intrasacular suture of the aneurysm would have been attempted, this I am sure would have resulted in failure, and most likely in gangrene of the leg.

CASE 3—A. A., a colored man, aged 39 entered the hospital on Aug 17, 1927, suffering from gunshot wounds of the chest and arm. One of the bullets had penetrated the right axillary region and had produced a huge hematoma in the right axilla. There was also considerable swelling in the region of the right shoulder. The immediate swelling subsided and about one month after admission a small swelling was noticed in the right axilla just at the junction of the axillary and brachial arteries. This swelling gradually increased in size and became pulsating. About six weeks after admission, the swelling was about the size of a lemon and showed all the classic signs of an aneurysm. Eight cubic centimeters of 100 per cent sodium iodide was injected directly into the aneurysm and a roentgenogram was made which showed that the aneurysmal sac and the arteries below it were well injected. Immediately after the injection the extremity showed some paleness which rapidly disappeared without detrimental effects. One week later the patient was operated on and a metal clip was applied around the third part of the axillary artery and tightened until the radial pulse was practically obliterated. At the present time the aneurysm has almost disappeared and the circulation of the extremity shows signs of slight venous obstruction.

The profunda artery was here revealed, lying the brachial immediately adjacent to the sac of the aneurysm. It was found so intimately associated with the sac that the contemplated nitas intrasacular suturing was abandoned.



# METHOD

All experiments were performed on dogs under ether anesthesia and aseptic technic. Severed gut obstructions were established largely in the duodenum, a few were established in the lower ileum and one in the lower part of the descending colon. At the point selected for obstruction, the gut was severed between crushing clamps<sup>11</sup> and the ends of the bowel inverted<sup>12</sup> much as the stump of the appendix is treated in appendectomy.

The effect of giving salt solution was noted in some of the dogs with duodenal obstruction. In several animals gastro-enterostomy was established in addition to the high duodenal obstruction. Some of these animals were given salt solution, others were not. Division of the stomach beneath the diaphragm was practiced in a few animals with and without the subcutaneous administration of salt solution. In two animals the esophagus was ligatured in the neck. Duodenal fistulas were established in a number of animals. Salt solution was given to some of them.

When sodium chloride was administered, it was given subcutaneously, with a 50 cc syringe. In most instances, from 250 to 400 cc of a 2 per cent solution was given once a day. A 1 per cent solution was given to a few animals, 400 cc being given twice a day. The blood urea and chlorides were determined daily on all animals. Blood was obtained from the jugular vein or the vein on the outer aspect of the hind leg of the dog. Some of the animals were placed in metabolism cages and the nitrogen output in the urine determined. The nonprotein nitrogen in the urine was determined by the micro-Kjeldahl method of Folin and Denis<sup>13</sup> and the urea nitrogen of the blood by the method of Van Slyke and Cullen<sup>14</sup>. The blood chlorides were determined according to the method described by Gettler<sup>15</sup>.

Two of three dogs in which severed gut obstructions were established in the duodenum about 15 cm beyond the pylorus died within seventy-two hours. The increase of the nonprotein nitrogen in the blood and decrease of the chlorides observed by previous investigators<sup>16</sup> were

11 In some earlier experiments, it had been observed that animals occasionally survived ligature obstructions. In the animals that died or were killed, the obstruction was usually found incomplete at necropsy.

12 The distal end of the bowel, when the division was made in the small intestine, was anchored to the abdominal wall because it was noted that in some of the early animals in which this procedure was not practiced, intussusception of the distal loop not infrequently occurred.

13 Folin, O., and Denis, W. Nitrogen Determination by Direct Nesslerization, I. Total Nitrogen in Urine, J Biol Chem **25** 473, 1916

14 Van Slyke, D. D., and Cullen, G. E. A Permanent Preparation of Urease and Its Use for Rapid and Accurate Determination of Urea, J A M A **62** 1558 (May 16) 1914

15 Gettler, A. O. A Method for the Determination of Death by Drowning, J A M A **77** 1650 (Nov 19) 1921

16 Cooke, J. V. Rodenbaugh, F. H., and Whipple, G. H. Intestinal Obstruction, A Study of Non-Coagulable Nitrogen of the Blood, J Exper Med **23** 717, 1916

Connors, J. F., Killian, J. A., and Eisberg, H. B. Chemical Changes in the Blood in Intestinal Obstruction, Proc Soc Exper Biol & Med **20** 357, 1923.

Haden and Orr (footnote 8, first reference). Tillotson, W., and Comfort, C. W. The Total Nonprotein Nitrogen and the Urea of the Blood in Health and in Disease as Estimated by Folin's Methods Arch Inter Med **14** 620 (Nov) 1914.

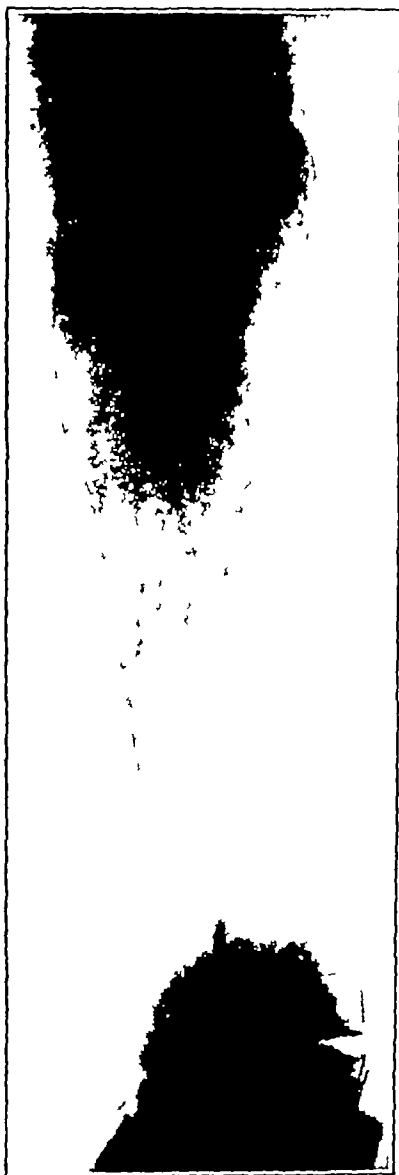


Figure 1

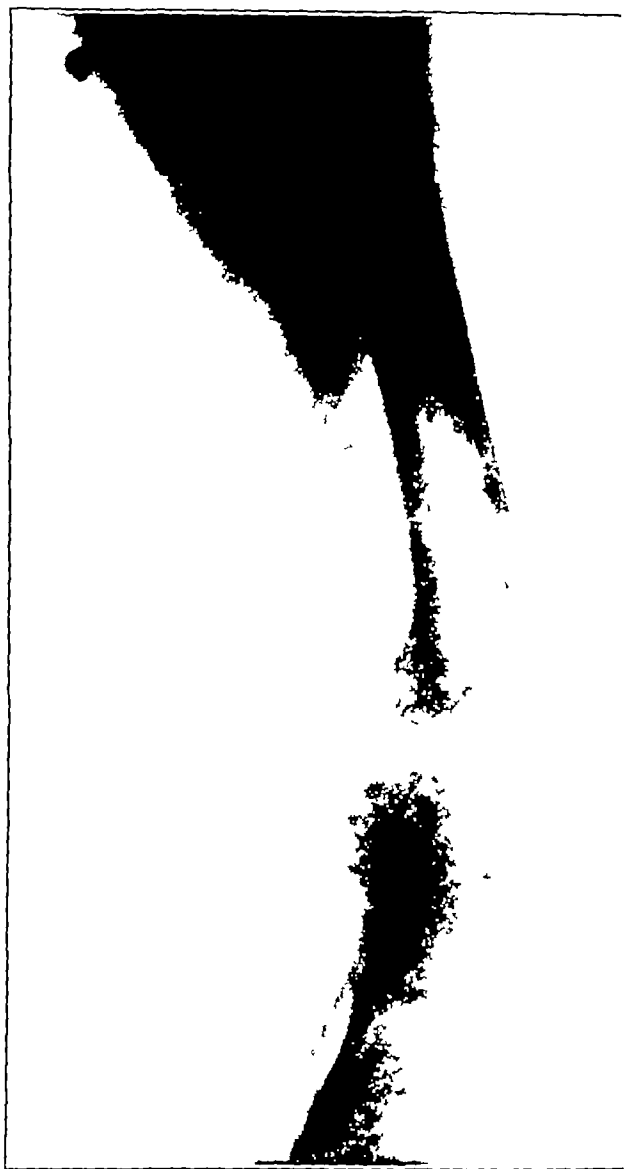


Figure 2

Fig 1 (case 1) —Arterial tree after ligation of the artery above and below the aneurysm. The roentgenogram of intra-arterial injection of arteriovenous aneurysm made before operation was lost.

Fig 2 (case 2) —Intra-arterial injection of popliteal aneurysm showing enormously dilated femoral artery above with aneurysmal sac in popliteal space.

noted The third dog survived the procedure seven days.<sup>17</sup> Two dogs with obstruction in the lower part of the ileum survived four days. In a group of ten dogs given from 250 to 400 cc of a 2 per cent salt solution subcutaneously, the average length of life following duodenal severed gut obstruction was seven days. Two animals with this type of obstruction, were given saline solution for one week, one animal survived eighteen days, the other, nineteen.

Severed obstructions of the same nature were made in two dogs, and a posterior gastro-entrostomy was added beyond the duodenojunal flexure. One of these animals survived two days, the other, nine. The changes in the blood chemistry present in animals with simple duodenal occlusion were observed. In two other animals, severed duodenal obstructions were established, gastro-entrostomy was performed and a linear division of the pyloric sphincter muscle (Rammstedt procedure) without incising the mucosa was practiced. The outcome was the same as in the animals in which the pyloric sphincter was intact, both died within seventy-two hours. Three dogs with a severed duodenal obstruction and an added gastro-entrostomy, were given saline subcutaneously for a week. One died two weeks after the original procedure from an obstruction due to an adhesive band lower in the intestinal tract. Another died from an extensive slough over the hind quarters where the hypertonic saline had been injected twelve days after the obstruction was established. The other dog was alive and well almost six months later. This dog became somewhat emaciated during his convalescence and vomited considerably. Occasional vomiting was noted at the last observation. Material alteration in the blood metabolites was not observed in any of the latter animals to which salt solution was given temporarily. An increased excretion of nitrogen, however, was observed in the urine. Complete duodenal fistulas were established in three animals at the same level at which obstruction had been established in the other dog. The proximal segment was drawn out through a small stab wound and sutured to the abdominal wall, leaving the lumen patent. The distal end was inverted and anchored to the parietal peritoneum. These dogs died three days later. The changes in the blood chemistry noted by Walters, Kilgore and Bollman,<sup>18</sup> were observed in these animals. Two of three other animals in which the same operative procedure was performed but which were given saline solution survived eight days, the other lived five days.

By making a T incision in the left rectus muscle in one dog, easy access was had to the cardiac end of the stomach. This was divided as

<sup>17</sup> Throughout this work on intestinal obstruction, it has been noted that larger dogs stand obstruction better than small animals.  
<sup>18</sup> Walters, W., Kilgore, A. M., and Bollman, J. L. Changes in the Blood Resulting from Duodenal Fistula, J. A. M. A. 86 186 (Jan 16) 1926

because of fear of destroying the profunda. If the profunda had been obstructed, the entire collateral circulation, which was between the profunda and the circumflex vessels, would have been cut off, this would have resulted in gangrene of the arm.

CASE 4—Mrs. J. C., white, aged 28, who entered the hospital on April 10, 1925, gave a history of having been delivered of a postmature, full term, dead fetus four weeks previously. Following this she had chills, fever and exquisite pain on the slightest pressure over the middle of Poupart's ligament. All the symptoms were aggravated, the leg became markedly swollen, and the foot began to turn black. A diagnosis of moist gangrene from thrombosis of the left femoral and iliac vessels was made. About six weeks later, a line of demarcation had been established at the ankle joint. At this time, 15 cc. of 100 per cent sodium iodide was injected into the femoral artery, and a roentgenogram was made which showed that the arteries of the leg were normal. There was

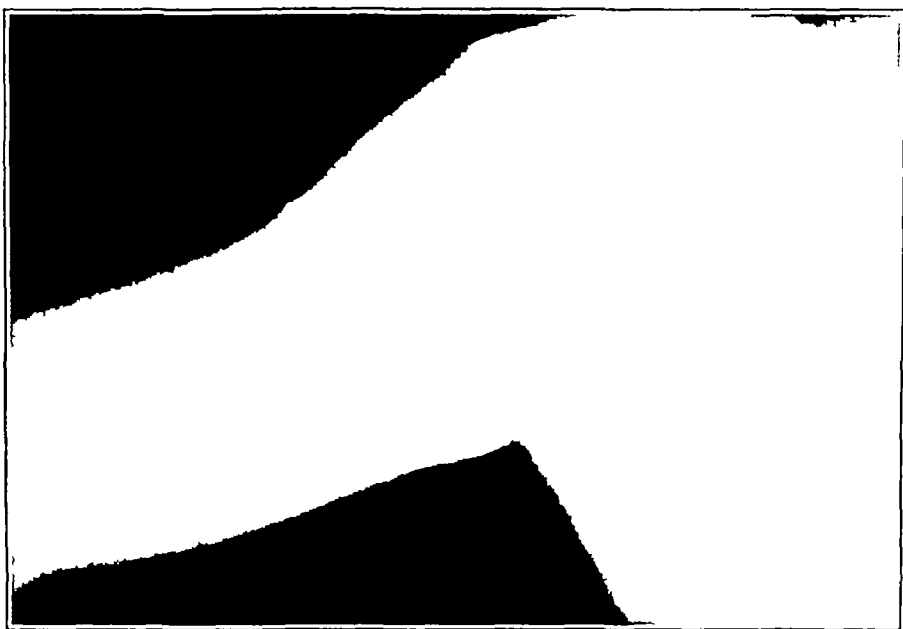


Fig. 3 (case 3)—Intra-arterial injection showing aneurysm of first part of brachial artery revealing profunda branch coming off close to the aneurysmal sac.

some blanching of the healthy tissue, and the gangrene which had become stationary immediately spread up the leg several inches. Two months later the leg was amputated at the seat of election. Primary union occurred, and the patient was discharged from the hospital on September 15 in a good condition.

The deleterious effect was evidently due to the irritation of the vessels by the solution, because the venous obstruction caused the drug to be retained overly long before it was returned to the general circulation.

CASE 5—A. P., a colored woman, aged 60, entered the hospital on Feb. 24, 1925, with a condition diagnosed as senile gangrene of the right foot, which extended up to the midtarsal joint. It was the usual dry type. After six weeks of expectant treatment, sodium iodide was injected into the femoral artery. Following the injection the leg became cold, and the circulation below the knee was seriously affected. Two days later, the patient died.

The dog high as possible and both proximal and distal ends inverted. The dog lived one day. In another animal the same procedure was repeated, but 400 cc of water was poured into the peritoneal cavity. The outcome was the same. In four other animals 400 cc of a 2 per cent sodium chloride solution was given once a day following the same procedure. One of these animals survived for a day, another, two days, a third dog lived seven days, and the other twelve days. Two dogs with ligation of the cervical esophagus died within two days.

In one animal, the descending colon was divided as low down as possible and the ends turned in. This dog survived the procedure for forty-two days. The increased nonprotein nitrogen found in the blood of animals with severed duodenal obstruction was not observed in this animal. The nitrogen excretion in the urine, however, was increased. At death the animal was markedly emaciated. The entire intestine was enormously distended, and the lower portion of the obstructed colon was packed tight with fecal material.

Two dogs were starved and dehydrated by being deprived of water for three days. Severed gut duodenal obstructions were then established. One of these animals survived for eight days. The changes in the blood chemistry found in dogs with simple duodenal obstruction were also observed in these animals. Two dogs with ileal obstructions were similarly starved and dehydrated without materially prolonging their lives.

Two dogs were dehydrated by being deprived of water and were given subcutaneous injections of pilocarpine and apomorphine to induce vomiting and added dehydration. Low values for blood chlorides were obtained in these animals without elevation of the blood urea nitrogen. The nitrogen output of the animals kept in metabolism cages was consistently high following duodenal obstructions. The urinary excretion of nitrogen was also increased in the animals that were given salt solution subcutaneously, and in which no material increase of the blood nonprotein nitrogen was observed.

# COMMENT

Clinicians and investigators alike concede the more serious import of obstructions high in the intestinal tract. In these experiments it has been recounted that dogs with duodenal obstruction usually die in seventy-two hours, whereas a dog with a severed gut obstruction low in the colon survived the obstruction for forty-two days. Starvation could well be assigned as the cause of death of the latter animal, in the case of the former, it is generally held that the formation and absorption of a potent toxin is responsible. When, however, saline is administered to the animal with duodenal obstruction, his life may be prolonged for three weeks, as many investi-

The patient was old, and her general condition unfavorable, however, her death was apparently hastened by the injection

CASE 6—B F S, a white man, aged 86, entered the hospital on Feb 4, 1926, with a history of having been hurt in an automobile accident. Physical examination at this time showed a fairly well nourished man with abrasions on the right side of the chest and tenderness there, but roentgen-ray examination did not show fracture. While in the hospital the patient complained of a

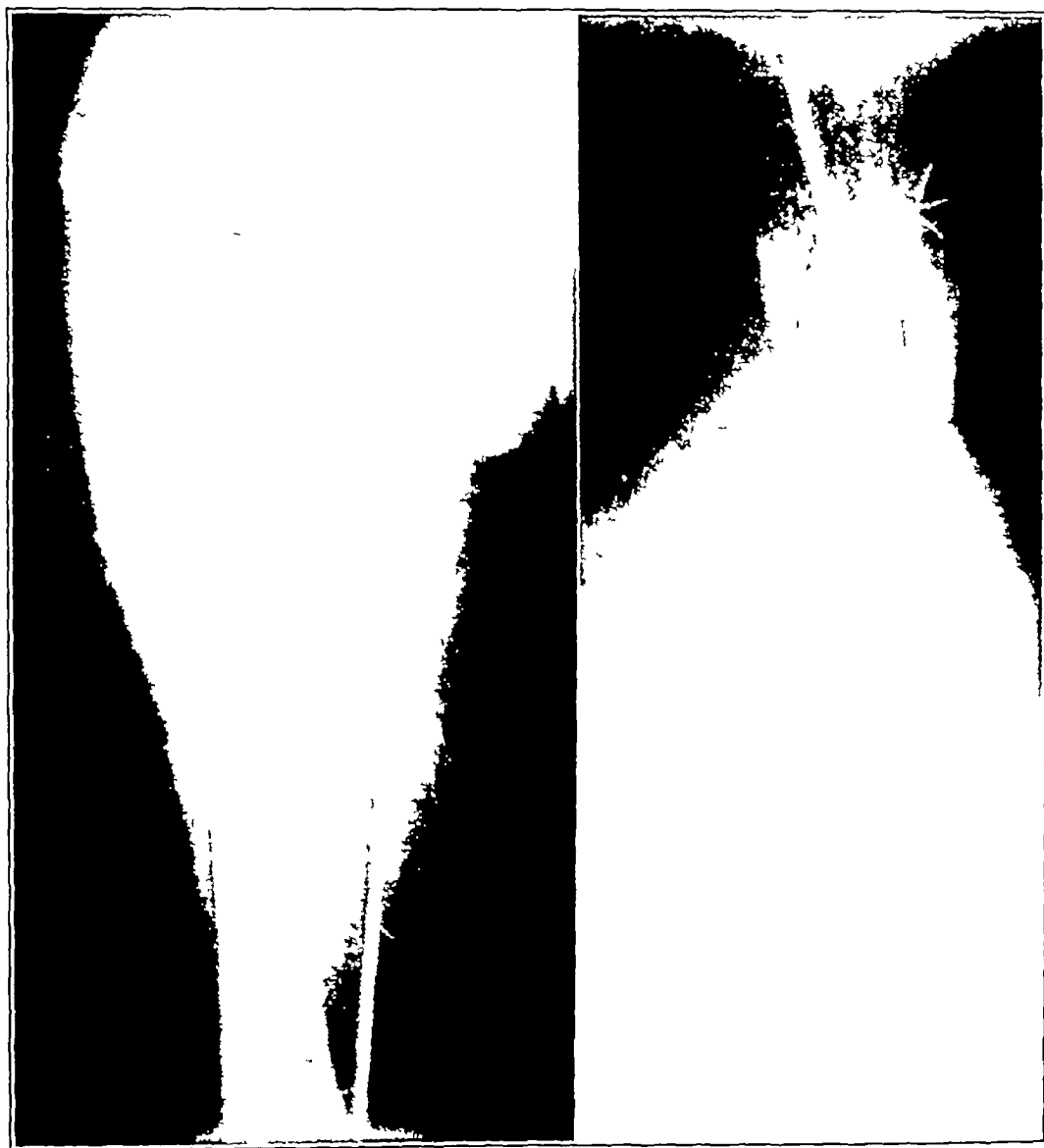


Fig 4 (case 4)—Arterial tree showing case of moist gangrene spreading higher following arterial injection

feeling of numbness in both feet and inability to move them as he had formerly done. The right foot showed a small gangrenous mass on the first and second toes. The great toe was involved to the size of about a five cent piece. Anesthesia involved all the toes of the foot. Both feet were numb, and the patient was unable to flex the metatarsal and phalangeal joints. There was



some pain involving the affected area. Touch and pressure sense was lost over the discolored portions, but pain, especially on the application of heat, was present. This numbness of the toes had become progressively worse during the last several years. The numbness during the last few days began to involve the right hand and fingers, particularly the fifth finger. The predominant loss was that of the sense of touch. The condition in the left leg became



Fig 5 (case 5) —Arterial tree in case of senile gangrene. One view shows the leg upside down. While the main arterioles are open in both anterior and posterior tibias, senile gangrene occurred in the foot due to the obstruction of the arterioles and capillaries.

progressively worse while the patient was in the hospital. It became cold, motion was lost, and the leg was painful. On February 8, 15 cc of 100 per cent sodium iodine was injected into the left femoral artery, and roentgeno-



does not affect the outcome. When, however, sodium chloride solution is given to such an animal for a short period, changes in the blood do not occur, and he is able to live for a long time. Such an animal continues in good health except for the emaciation incident to the vomiting occasioned by the obstructed segment.

The virtue of sodium chloride in the treatment of the animal with a fistula or obstruction high in the intestinal tract probably represents, therefore, replacement therapy. A protective mechanism exercised through a detoxifying agency is unlikely. McCallum and his co-workers<sup>30</sup> and Gamble and Ross<sup>31</sup> are also of this opinion. It has been demonstrated by Haden and Orr<sup>32</sup> that other combinations of the sodium or chloride radical will not ward off early death in animals with duodenal obstruction. Hypertonic dextrose solutions similarly fail to do so. Walters and Bollman<sup>19</sup> have made the same observation in dogs with duodenal and gastric fistulas. Just why sodium chloride apparently alone should be able to fulfil this function is difficult to surmise, but the suggestion of Gamble and Ross<sup>31</sup> that it is particularly suited to replace the lost fluid and fixed base is probably correct.

Whipple and his co-workers<sup>33</sup> have shown that an increased destruction of protein occurs in intestinal obstruction. Haden and Orr<sup>33</sup> have made the same observation. Though injury to the kidney obtains in simple occlusion of the bowel, it is not likely that the increase in non-protein nitrogen of the blood is due to renal insufficiency, as has been suggested.<sup>34</sup> The fact that nitrogen is excreted in excess and that phenolsulphonphthalein is normally excreted<sup>35</sup> shows that renal failure is not present.

The increased excretion of nitrogen probably partakes of an acceleration of general body breakdown of protein. At any rate, the necrosis of the ends of the inverted bowel is not in itself responsible for the increased destruction. An experiment often cited to indicate that death in obstruction is due to the absorption of potent toxins from the intestine is that per-

- 30 MacCallum, W. B., Lintz, H., Vermilye, H. M., Leggett, T. H., and Boas, E. (footnote 7, third reference)
- 31 Gamble, J. L., and Ross, S. G. The Factors in the Dehydration Following Pyloric Obstruction, J Clin Investigation 1 403, 1925
- 32 Haden and Orr (footnote 8, first and second reference)
- 33 Whipple, G. H., Cooke, J. V., and Stearns, T. Proteose Intoxications and Injury of Body Protein, J Exper Med 25 479, 1912
- 34 Brown, G. E., Eusterman, G. B., Hartman, H. R., and Rowntree, L. G. Toxic Nephritis in Pylorus and Duodenal Obstruction, Renal Insufficiency Complicating Gastric Tetany, Arch Inter Med 32 425 (Sept) 1923
- 35 Connors, J. F., Killian, J. A., and Eisberg, M. B. (footnote 16, second reference) Louria, H. W. The Blood Urea Nitrogen in Acute Intestinal Obstruction, Arch Inter Med 27 620 (May) 1921

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pital as showing hypertrophy of the exophthalmic goiter type, and in the remaining five patients (who had taken iodine before operation) were found the "typical exophthalmic goiter hypertrophy and hyperplasia of an iodine remission" (Rienhoff). Three of the five patients who took compound solution of iodine while in the hospital showed an average remission from iodine, with a drop in the basal metabolic rate from 37 to 15 per cent above normal, from 55 to 13 per cent above normal and from 57 to 31 per cent above normal, respectively. Three other patients had taken iodine just before entering the hospital. In the other five cases, iodine was not given. In only one of the thirteen patients was there evidence of heart disease (mitral stenosis and auricular fibrillation). Two other patients had edema, in one probably as a result of slight myocardial insufficiency and in the other of marked secondary anemia (hemoglobin content 58 per cent).

Of the other two patients in this group who did not show a striking degree of hypertrophy and hyperplasia, sections from the gland of one showed a small localized amount of hypertrophy and hyperplasia in a cystic area which contained an abundance of colloid. He was extremely obese, his postoperative basal metabolic rate was 26 per cent above normal and he had had a cystic nodule for five years. He presented doubtful clinical evidence of hyperthyroidism. In sections from the gland of the other patient it was possible to demonstrate three types of cellular structure—(a) typical "fetal" adenoma, (b) involution of the gland without hypertrophy and hyperplasia and (c) localized areas of hypertrophy and hyperplasia. When at rest, his pulse rate was 60 beats to the minute, and his basal metabolic rate fell from 28 per cent above normal to '16 per cent above normal after two days' rest in bed without medication. He complained only of tremor and loss of weight. Of this younger group, the eleven patients who were frankly thyrotoxic showed marked evidence of hypertrophy and hyperplasia of the exophthalmic goiter type which satisfactorily explains their clinical picture.

Except in two patients whose hemoglobin content (Sahli) was 58 and 60 per cent (the latter being the patient previously mentioned as having mitral stenosis and auricular fibrillation) anemia was not present. Including these two patients, the average hemoglobin content was 74 per cent, the average duration of the goiter (after its discovery) was four and a half years, and the average blood pressure was systolic 123 and diastolic 68. Three patients showed fairly high basal metabolic rates, 67, 65 and 55 per cent above normal, respectively, the average elevation above normal was 35 per cent. Although exophthalmos was not noted in any one of these cases, four patients showed a slight lagging of the lid (von Graefe's sign).

formed by Sauerbruch and Hyde<sup>36</sup> They denuded the abdominal wall of two rabbits and sutured the skin of one to that of the other Later, when a good crossed circulation had been established, an obstruction was created in one, following which the same toxic symptoms and death also occurred in the animal in which obstruction had not been established The outcome undoubtedly would have been the same if a duodenal fistula had been established in one of the animals

Sugito<sup>37</sup> claims to have isolated a toxin in the blood returning to the liver from the intestine in the mesenteric veins in dogs with intestinal obstruction When the serum from blood thus obtained was injected into the peritoneal cavity of rats, toxic symptoms were observed that were not elicited following the injection of blood from animals without obstructions Wilkie<sup>38</sup> and McLean and Andries,<sup>39</sup> however, have transfused large amounts of blood from dogs with intestinal obstruction to normal animals, without any untoward effect Wilkie also removed the intestinal contents from a dog with obstruction and placed them in the obstructed intestine of another dog without hurrying the development of toxic symptoms<sup>40</sup> A number of investigators<sup>41</sup> have demonstrated that intestinal contents obtained from animals with intestinal obstruction do not elicit toxic symptoms when placed in the bowel of a normal animal

Schonbauer<sup>42</sup> and Chenut<sup>43</sup> contended that abnormal absorption in simple obstruction may occur via the peritoneal cavity Schonbauer stated in support of his contention that iodine placed in the bowel of a dog with intestinal obstruction can be recovered from the peritoneal cavity He believed that death during obstruction is due to toxins permeating the wall of the bowel and being absorbed from the peritoneal cavity rather than to abnormal absorption from the lumen of the intestine Schonbauer and Löffler stated<sup>44</sup> that the antitryptic titer of the blood of

36 Sauerbruch, F, and Hyde, M Weitere Mitteilungen ueber die parahiose bei Warmbeutern mit versuchen ueber Ileus und Uramie, *Ztschr f Exper path u Therap* 6 33, 1906

37 Sugito, S Ueber die Todesursache bei Ileus (Intoxicationstheorie), *Mitt a d med Fak d k Univ Kyushu u Fukuoka* 9 229, 1924

38 Wilkie, D P D Acute Intestinal Obstruction, *Lancet* 1 1135, 1922

39 McLean, A, and Andries, R C Ileus Considered Experimentally, *J A M A* 59 1614 (Nov 2) 1912

40 Wilkie, D P D Experimental Observations on the Cause of Death in Acute Intestinal Obstruction, *Brit M J* 2 1064, 1913 (footnote 38)

41 Chenut, A L'Eperimentation dans l'occlusion mecanique du jejunoleon, *Rev d chir* 45 474, 1926 (footnote 38)

42 Schönbauer, L Die Fermente in Ihrer Beziehung zu gewissen der Gallenblase und zum Ileus, *Arch f klin Chir* 130 427, 1924

43 Chenut (footnote 41, first reference)

44 Schönbauer, L, and Eöfler, E Ueber Ileus-serum, Experimentelle und Klinische Untersuchungen, *Wein klin Wchnschr* 38 135, 1925

has been assumed by many to account for the facts already mentioned.<sup>12</sup> Dilution alone must be an ineffective neutralizing mechanism, since these fluids are themselves either neutral or barely alkaline.<sup>4</sup> For example, to reduce the acidity of gastric juice from 1.40 to 3.5, it would be necessary to add three times its volume of a neutral fluid, whereas only three fourths its volume of pancreatic juice would be required, since it can completely neutralize more than its own volume of tenth normal hydrochloric acid. That the pancreatic juice is actually responsible for this regulation is made to appear more likely by the results of the experiments recorded in this article. All the foregoing factors have remained intact in them. By mere elimination of the external pancreatic secretion, therefore, neutralization in the stomach could not occur, and the contents of the stomach were constantly more acid than normal.

One finds frequent references in the literature to the rôle of bile in the neutralization of gastric acidity, the erroneous assumption being that bile is alkaline in reaction. All investigations have shown that hepatic bile is neutral. According to Drury, McMaster and Rous,<sup>13</sup> the influence of the gallbladder is such as actually to make the bile acid before it arrives at the intestine ( $pH$  from 5.1 to 6.8). It must be unlikely, therefore, that bile plays any part in the neutralization of gastric acidity.

Duodenal antiperistalsis, of course, must take place before pancreatic juice can enter the stomach. Roentgenologists have apparently rarely observed it,<sup>14</sup> though such evidence is merely negative. Recently, Bolton and Salmond<sup>15</sup> examined 100 persons, including many normal persons, with this point particularly in mind. They describe four different types of peristaltic movements in the duodenum. One of them consists of a contraction in the proximal duodenum which propels the opaque medium toward the pylorus, which, by its relaxation, permits the passage of the medium into the stomach. Such a relaxation with visible reflux was actually seen but six times, though the duodenal antiperistalsis initiating it was seen in 93 per cent of the cases.

The frequent finding of bile in the stomach can be explained only by duodenal reflux. It is not found constantly, it is true, it is known, however, that bile is not continuously discharged into the duodenum, but is dependent on periodic emptying of the gallbladder.<sup>16</sup> In general,

12 Ormer A. Arch f d ges Physiol 186 124, 1917

13 Drury D R, McMaster, P D, and Rous, P. J Exper Med 39 403 1924

14 Eisen P. Radiol 4 388, 1923

15 Bolton C, and Salmond R W A. Lancet 1 1230 1927

16 McMaster, P D, and Elman R. J Exper Med 44 173, 1926. Copher, G. H. and Kodama S. Regulation of Flow of Bile and Pancreatic Juice in Duodenum. Arch Int Med 38 647 (Nov) 1926

patients suffering from intestinal obstruction is increased, and they recommended the use of an antitryptic ferment. Chenut<sup>43</sup> has examined histologically the intestinal wall in cases of simple obstruction and has observed evidence of damage to the mucosa at and above the level of obstruction. He found muscular and mucous and submucous layers thinned out. The epithelium over the intestinal villi appeared desquamated in areas.

In strangulating types of obstruction when gross evidence of damage to the intestinal wall such that the bowel is no longer viable is present, the bowel undoubtedly becomes permeable to the products of autolysis of the wall of the bowel consequent on the strangulation and to the contents within the lumen as well. When the viability of the wall of the bowel in simple obstruction is threatened by the distention of the intestine, permeation of the wall by toxins and absorption via the peritoneal cavity no doubt may also occur. As has been pointed out previously,<sup>10</sup> however, it is unusual to observe destructive changes in the wall of the bowel during simple occlusion. Distention ulcers or the gangrenous patches that occur on the antimesenteric border of the strangulated intestine are infrequently observed in simple obstruction. We have observed them frequently in closed loop obstruction with the continuity of the remainder of the tract reestablished. The tension in such a loop with both ends closed must, therefore, be much greater than in simple severance of the continuity of the bowel.

The fact that dogs with an obstruction high up in the severed gut can live for three weeks after having been given saline solution subcutaneously for a few days militates against the theory of the migration of toxins through the wall of the bowel and their absorption via the peritoneal cavity in simple obstruction. A great amount of toxin was not absorbed through the distended wall of the bowel in the animal with an enormously distended intestine which lived forty-two days following severed gut obstruction in the descending colon. The absorption from the bowel via the peritoneal cavity could also not have been great in the animals with duodenal occlusion which survived the procedure for almost three weeks after a few days of subcutaneous administration of salt solution and in which the obstructed segments were found uniformly markedly dilated.

A denial is not made of the suggestion that in simple intestinal obstruction absorption may be increased over that present in the normal bowel, but evidence of it has not been elicited in these experiments. The more rapid death when the obstruction occurs high up in the intestine, however, is not accounted for by the formation and absorption of a more potent toxin than that present when the obstruction is low down in the bowel, the more likely cause is the rapid dehydration and loss of body chlorides attending obstruction of the upper part of the intestinal tract.

reverse peristalsis is not uncommon in the small intestine, as pointed out so extensively by Alvarez,<sup>17</sup> and its infrequent visualization in the duodenum may be due to the fact that it is not being looked for and to the fact that the duodenum turns posteriorly, thus making it difficult to be seen with the fluoroscope in its entire course.

Direct evidence that pancreatic juice is regurgitated into the stomach would be furnished by the finding of pancreatic ferments in the gastric contents. This has indeed been the case. Boas<sup>18</sup> apparently was the first to make such examinations, he found the pancreatic ferments in a great many persons, including those who were normal. Trypsin, the most characteristic enzyme, present only in the pancreatic juice, was recovered from healthy stomachs nearly twenty years ago by a great many observers, particularly after the giving of a test meal of olive oil.<sup>19</sup> More recently, Rehfuess and Hawk<sup>20</sup> found it constantly in the fasting contents of the stomachs of normal persons. Iwanow,<sup>21</sup> in extensive observations on human beings, amply confirmed their observations. That trypsin may not be found when the contents are acid is due to the fact that it is destroyed in an acid medium.<sup>22</sup> Negative tests, therefore, are not conclusive. The frequent demonstration of trypsin in the stomach, on the other hand, can mean only that reflux of pancreatic juice has occurred.

The clinical applications of these observations chiefly concern the meaning of variations in gastric acidity found in real or supposed disease of the gastro-intestinal tract. The hyperacidity frequently found in cases of peptic ulcer, for example, has been ascribed to hypersecretion and the absence of, or low values for, acid in certain cases of so-called achylia to hyposecretion. From the evidence herein reported, it would seem that variations in the degree of regulation of pancreatic juice into the stomach may well be the important factor. A diminished reflux would permit the acidity to mount and account for the finding of hyperacid contents. An increased reflux, on the other hand, would so rapidly neutralize the acidity produced after a test meal that a low acidity or absence of acidity would be found. Indeed, in a recent

17 Alvarez, W. C. The Mechanics of the Digestive Tract, New York, Paul B. Hoeber, 1922.

18 Boas, J. Ztschr. f. klin. Med. 17 155, 1890.

19 Mahlenbrey, J. Zentralbl. f. d. ges. Physiol. u. Path. d. Stoffwechs. 4

643, 1909.

20 Rehfuess, M. E., and Hawk, P. B. Gastric Analysis. Interdigestive Phase or Principle Governing the Resting Stomach, J. A. M. A. 76 564 (Feb. 26) 1921. Spencer, W. H., Meyer, G. P., Rehfuess, M. E., and Hawk, P. B. Am. J. Physiol. 39 459, 1916.

21 Iwanow, W. Arch. f. Verdauungschr. 38 223, 1926.

22 Kuda, T. Biochem. Ztschr. 15 473, 1909. Deutsch, G., and Rurup, H.

Deutsches Arch. f. klin. Med. 138 165, 1922.

That liver insufficiency does not play a great rôle in simple obstruction, as has been suggested,<sup>45</sup> is apparent from the injections of histamine into the mesenteric veins of dogs with intestinal obstruction, described in a previous paper. The liver of animals with intestinal obstruction still possessed the same slightly detoxifying action for histamine observed in the liver of normal animals. The presence of a high blood fibrin in animals with an obstruction in the upper part of the intestine, as observed by Haden and Orr,<sup>46</sup> is also against such an assumption.

The increase in the excretion of nitrogen in the urine could be due to a toxic action occasioned by abnormal absorption, but the same obtains in obstruction of the cervical esophagus. Is it likely that absorption plays any great rôle in the death of such an animal?

#### SUMMARY

Obstruction of the upper part of the intestine is much more serious than obstruction low down in the colon. An animal with the former type of obstruction dies sooner because dehydration and loss of chlorides occur more rapidly. Subcutaneous administration of saline to such an animal prolongs his life and obviates the alteration in blood chemistry noted in animals with duodenal obstructions to which salt solution is not given. An increased excretion of nitrogen, however, also occurs in the urine of animals with duodenal obstruction to which salt has been given. A temporary administration of saline is just as efficient in prolonging the animal's life as continued daily administration. Therefore, the virtue of the remedy cannot lie in any detoxifying mechanism. The fact that animals with gastric or duodenal fistulas die as quickly as dogs with obstructions at the same level and with the same changes in the chemistry of the blood and increase in nitrogen excretion in the urine, and the fact that the administration of saline prolongs the life of such an animal also indicate that the virtue of the drug lies in substitution therapy. Dogs with duodenal obstruction on which gastro-enterostomy has been performed can live indefinitely when given salt solution for a few days. In such an animal, the conditions are right for permanent recovery when the dehydration and the loss of the contents of the stomach incident to the obstruction have been ameliorated by the administration of saline. The animal with esophageal obstruction does not lose chlorides and fluid by vomiting, but the life of the animal can be prolonged by the administration of saline. On the same basis of loss of fluid and fixed base from the body, some alteration in the permeability of tissue is necessary to

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<sup>45</sup> Werelius. A. Is Death in High Intestinal Obstruction Due to Liver Insufficiency? *J. A. M. A.* **79** 535 (Aug. 12) 1922.

<sup>46</sup> Haden and Orr. Blood Fibrin in Upper Gastro-Intestinal Tract Obstruction. *J. Exper. Med.* **45** 427, 1927.



# THIRTY-FIFTH REPORT OF PROGRESS IN ORTHOPEDIC SURGERY

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(Continued from page 1126)

## MISCELLANEOUS

*Orthopedic Surgery in Sweden*—Hauser<sup>39</sup> has given an interesting account of orthopedic developments in Sweden growing out of national, social, and health insurance legislation. Sweden early recognized that it was advisable for the community to assume the responsibility of alleviating the circumstances of the poor and needy, and a comprehensive law was passed for the benefit of all who were in need of social aid. The provisions of this law include the medical care of invalids and cripples. The system of pensioning invalids, part of the socialistic national insurance scheme which has been adopted, also influences the practice of orthopedic surgery, in that it has been found expedient to cure, or at least reduce as far as possible, invalidism before the amount of disability is fixed and a pension allocated. Under the supervision of a central committee for the care of cripples, the state organized three orthopedic centers, one at Stockholm, one at Helsingfors and one at Gothenburg. Each center comprises several units besides the diagnostic and hospital sections, and includes a home for crippled children, vocational training schools, special hospitals for the care of patients with tuberculosis of the bones and joints, and three seaside sanatoriums.

*Summary of Literature Relating to Posture*—Schwartz<sup>40</sup> made a survey of 134 articles relating to posture, all of any importance that could be found in the literature. From this study he also concluded that most authors are in agreement on the following statements: 1. The

39 Hauser E D M J & Rec 125 789 (June 15) 1927  
40 Schwartz L Pub Health Rep 42 1219 (May 8) 1927

explain the death of an animal with esophageal obstruction or a rabbit with duodenal obstruction that does not vomit. In the animal with ileal or colonic obstruction the marked increase of nonprotein blood nitrogen and low values for blood chlorides are not obtained. The administration of saline in low obstruction would therefore not afford the same protection as it does to animals with duodenal obstruction.

#### CONCLUSIONS

- 1 The explanation of the rapidly fatal issue in dogs with obstruction in the upper part of the intestine is to be found in the rapid dehydration and loss of chlorides accompanying occlusion of this portion of the bowel.

- 2 The virtue of saline solution in the treatment of patients with obstruction in the upper part of the intestine does not lie in any protective or detoxifying influence, but in its value in replacing the chlorides and fluid lost.

- 3 Evidence was not obtained to show that dogs with simple obstruction in the upper part of the intestine died as the result of absorption of toxins from the obstructed bowel.

- 4 Interference with the continuity of the upper part of the intestine (occlusions or complete external fistula) gives rise to an increased nonprotein nitrogen in the blood and low blood chloride values, an increase in the excretion of nitrogen in the urine also occurs. The administration of sodium chloride prevents the increase in the nonprotein nitrogen of the blood, but the urinary excretion of nitrogen continues to be high.

biped posture of man has been evolved from the quadruped posture 2 The body has not yet fully adopted itself to the biped posture 3 There are many physical disadvantages to the erect posture, but they are outweighed by the physical and mental advantages resulting therefrom 4 Good posture can be attained by having good health, taking enough exercise to keep the muscles strong and the joints supple, and continually assuming correct postures in the daily tasks 5 Fatigue is the most frequent cause of postural deformities in the industries 6 Continuous sitting or standing in any position is fatiguing 7 Change of posture at the will of the worker is the remedy for industrial fatigue 8 Industrial furniture should be so constructed as to fit the individual worker and to allow comfortable working conditions in both the sitting and the standing postures The author's personal comments are as follows 1 There is a lack of agreement in the various definitions of standards for good posture 2 Heredity, type of build, balance of muscle strength and tone have not been given sufficient importance in establishing standards for posture 3 It has not been established that faulty posture associated with certain diseases is the cause or result of these diseases 4 There is no universally satisfactory test for physical fitness

*Loose Bodies in Joints*—In a discussion of the pathogenesis of loose bodies in joints, Platt<sup>41</sup> classified them as follows

Group 1—Diseased joints The patients have usually passed middle age and the loose bodies are multiple The causes are osteo-arthritis and Charcot joints

Group 2—Otherwise Healthy joints Included in this group are the great number of patients with "osteochondritis dissecans" of Koenig Platt discussed the various theories as to the etiology of the condition without reaching any conclusion

Group 3—Synovial Chondromas It is probable that these bodies are actually tumors from rests of cartilage cells contained in the synovial membrane The bodies are usually multiple, may become detached, and may reattach themselves

*Madelung's Deformity*—Writing on the subject of Madelung's deformity, Catterina<sup>42</sup> set down the following conclusions 1 Madelung's deformity is characterized by an abnormal curve of the radius, followed by a subluxation, more or less marked, of the ulna, and is a disease that occurs in adolescence, especially in girls 2 Such lesions must be attributed to rickets Vigorous movements, as of dorsal flexion of the hand due to special occupations, may accentuate the pre-

41 Platt, Harry Brit M J 1 947 (May 28) 1927

42 Catterina, A Chir d org di movimento 10 517 (April) 1926

# PROBABLE INFLUENCE OF PANCREATIC JUICE IN THE REGULATION OF GASTRIC ACIDITY\*

ROBERT ELMAN, M D

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Drainage of the total external secretion of the pancreas, as already reported in a previous communication,<sup>1</sup> leads to increasingly severe vomiting in a few days, and, in about a week, to a fatal outcome. In the attempt to explain these symptoms of gastric irritability, a number of observations were made. The contents of the stomach were examined in most of the animals, and the behavior of gastric acidity was studied in a special way. The results will be presented in detail. They have suggested among other things that a reciprocal relationship exists between the alkaline pancreatic juice and the acid secretion of the stomach.

One aspect of this relationship has long been known, and the data herein contained adds further proof, that is, that the acid gastric juice, passed into the duodenum, is the normal stimulus of pancreatic secretion. Its discovery by Dolinsky<sup>2</sup> in Pavlov's laboratory has been amply confirmed by all subsequent observers. Others of Pavlov's pupils, notably Boldyreff,<sup>3</sup> brought forth evidence to support the idea that by reflux into the stomach the alkaline pancreatic juice neutralized and thereby regulated the level of gastric acidity. The latter hypothesis has remained more or less unconfirmed, though in the past few years much evidence in its support has accumulated. The observations herein recorded, as will be pointed out subsequently, not only seem to support this theory, but also tend to indicate that it may be an important phenomenon.

## METHODS

All observations were made on healthy adult dogs in which the total external secretion of the pancreas was being drained to the outside in a closed collecting system under aseptic conditions. This was possible by intubating the large pancreatic duct according to a method previously described<sup>1</sup>. In some dogs, provision was made for the return of the juice to the duodenum so that the secretion could be collected or reverted to the animal at will. The experiments here described were always performed during the first days of drainage and, therefore, before the onset of the severe vomiting.

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1 Elman, R., and McCaughan, J. M. J. Exper. Med. **45** 561, 1927.

2 Dolinsky, J. L. Diss., St. Petersburg, 1894.

3 Boldyreff, W. Ergebn. d. Physiol. **11** 121, 1911.

metatarsophalangeal joint which Mueller<sup>48</sup> previously described he added the report of three more. The clinical signs which he noticed were pain, tenderness and moderate swelling under the affected area. Roentgen-ray examination showed the medial sesamoid bone divided in from two to three fragments. The patients were from 20 to 30 years old. The cause, according to the author, was occupational strain. Histologic examination revealed necrotic areas in the bony tissue but not in the marrow. Mechanical irritation is supposed to have resulted in fragmentation of the necrotic bone. The treatment is stated to be support of the foot in patients with slight symptoms and operative excision when the symptoms are severe.

#### BONE, JOINT, AND TENDON SURGERY

*Spinal Anesthesia in Orthopedic Surgery*—Peabody<sup>49</sup> employed spinal anesthesia in 100 orthopedic operations and feels that it is particularly adapted to this class of cases. He found that it may be applied successfully in all procedures below the level of the dorsal spine, and his experience supplements that of others in establishing that it is a safe form of anesthesia.

*Pneumatic Hammer for Operation on the Bone*—Pitkin<sup>50</sup> described a pneumatic hammer for use in bone surgery. It is an adaptation of the Boyer U-type hammer manufactured by the Chicago Pneumatic Tool Company. The author described this hammer as a simple tool, sturdy, easily cared for, and safe.

*A Pendulating Bone Saw*—Not satisfied with the commonly used bone saws, Von Baeyer<sup>51</sup> constructed a pendulating saw. The ordinary rotary electric saw cannot be used in deep incisions unless a large blade is attached, and this represents a decided danger for the soft tissues. The author's saw is constructed with two swinging saw blades which work in different directions. They are driven in opposite directions with great rapidity and slight vibration by an electric motor. It is stated that an average sized long bone can be cut through in thirty seconds with this instrument.

*Operative Splinting of the Vertebral Column in Pott's Disease*—Lange<sup>52</sup> reported his experience with fifty-two patients with Pott's disease in whom he performed operative splinting of the spine by introducing celluloid splints of from 5 to 10 mm. in diameter and from 10 to 30 cm. in length. As he described it, his technique is to expose the spinous

- 48 Mueller, W. Beitr. z. klin. Chir. 138: 494, 1926.
- 49 Peabody, C. W. J. Bone & Joint Surg. 9: 450 (July) 1927.
- 50 Pitkin, H. C. J. Bone & Joint Surg. 9: 505 (July) 1927.
- 51 Von Baeyer, H. Zentralbl. f. Chir. 54: 2394, 1927.
- 52 Lange, Fritz. Surg. Gynec. Obst. 44: 668 (May) 1927.

The contents of the stomach were obtained with a small rubber tube connected at one end with a small perforated metal bulb such as is used for duodenal drainage. The animal was placed in a Pavlov frame while aspirations were performed. The acidity of the contents of the stomach were determined by titration with tenth normal sodium hydroxide with dimethyl-amino-azobenzene (Toepfer's reagent) as the end point for "free", and phenolphthalein for "total", acid. All samples were centrifugalized, since most of them contained a good deal of debris, particularly those removed from the fasting stomach. Only the clear fluid thus obtained was used in titrations.

To study the behavior of gastric acidity, a "test meal" of 200 cc of 0.5 per cent hydrochloric acid was used as originally devised by Boldyreff.<sup>4</sup> The solution was deliberately introduced by gavage, and specimens were aspirated every ten or fifteen minutes thereafter till the stomach was empty. Animals were deprived of food for from four to six hours, as a rule, and the contents of the stomach were emptied before the experiment was begun.

These experiments afforded opportunity, at the same time, to measure the effect of gastric acidity on the secretion of the pancreas. The collecting tube draining the gland was connected with a sterile graduate, and the amounts of fluid flowing were recorded at regular intervals, both before and after the acid was given.

#### EXPERIMENTAL OBSERVATIONS

*The Acid Stimulus to the Flow of Pancreatic Juice*—Fractional readings of the secretion of pancreatic juice following the introduction of 0.5 per cent hydrochloric acid into the stomach revealed an immediate and marked augmentation in the rate of flow. In the instance represented in chart 1, typical of a number of identical experiments, 51 cc of clear sterile secretion was collected during the course of one hour after the acid was given, or nearly three times the hourly average of the entire twenty-four hour output. Though this confirms the observations of other workers, I believe that my experiments are the first performed on unanesthetized animals yielding sterile juice from the entire pancreas and must, therefore, more closely represent the normal conditions.

*Failure of Acid Neutralization during Drainage of Pancreatic Juice*—Normally, acid solutions introduced into the stomachs of healthy dogs,<sup>4</sup> as well as healthy human beings,<sup>5</sup> are promptly and completely neutralized. This progressive lowering of acidity did not occur in animals in which the total pancreatic juice was flowing to the outside. It remained high, so that aside from a slight drop at first, the titrated acidity (against phenolphthalein) of the final sample was nearly the same as that of the first one. Twelve experiments were performed on eight different animals, and the results were the same. The curves in chart 2 represent an instance in a dog provided with an "altercursive" or double intubation which enables juice to drain to the outside or to

4 Boldyreff, W. Quart J Exper Physiol 8 1, 1914

5 Boldyreff (footnote 4) Apperly, F. L., and Cameron, G. Med J Australia 1 521, 1923

processes and separate the muscles from their sides down to the vertebral arches, "Each of the exposed spinous processes is perforated at the upper half and a loop of silk thread (no 12) is carried through the hole Through a second hole, drilled a little below or through the interspinous ligaments, the same loop of thread is returned to the other side, leaving thus a U-shaped loop of double thread on one side and the four open ends on the other. A celluloid splint which has been fitted exactly to the curve of the gibbus is inserted in the loop and another similar splint is placed on the other side of the spinous processes. The latter splint now being grasped between the free ends of the thread with a firm tension is securely tied to the spinous processes with a knot." The splints are fixed in similar fashion to each of the spinous processes. "They are then carefully covered up with muscles and fascia and sutured in the ordinary way with silk no 6." A plaster of paris dressing is used for six weeks and then a corset is worn for two years. Since 1924 he has used one splint of rust-proof steel and one of celluloid. In reference to Albee's and Henle's modifications Lange said that he preferred his own method, as it involved less danger of fracture of the splint, and the bone splint requires a prolonged dressing with plaster of paris and a stay in bed of six months or more.

[Ed. NOTE—Either of the methods commonly employed for obtaining bony fusion of the spine, Albee's or Hibbs', seems so far superior to Lange's method of securing fixation by means of celluloid splints that we consider it unnecessary to point out the advantages of the former or the disadvantages of the latter.]

*Transplantation of Trapezus Muscle for Paralysis of the Abductors of the Shoulder*—Mayer<sup>53</sup> described a method of transplantation of the trapezius muscle for paralysis of the abductors of the shoulder. It consists, briefly, in detaching the trapezius muscle from its bony insertion, lengthening it by means of an artificial tendon constructed of fascia lata, and suturing this tendon to the humerus near the deltoid insertion. To secure a satisfactory result it is necessary that the trapezius, the serratus magnus, and the pectoralis major, or the coracobrachialis or the biceps be present and active. The author reported the results in six patients one failure, one poor result, and four gratifying results.

*Habitual Dislocation of the Shoulder*—Still another operative procedure has been added by Carrell<sup>54</sup> to the long list of those previously described for the relief of habitual dislocation of the shoulder. The author's operation is stated to combine the principles of the suspension and reefing procedures. The suspension element is accomplished

53 Mayer, L. J Bone & Joint Surg 9 412 (July) 1927

54 Carrell, W B Habitual Dislocation of Shoulder, J A M A 89 948 (Sept 17) 1927

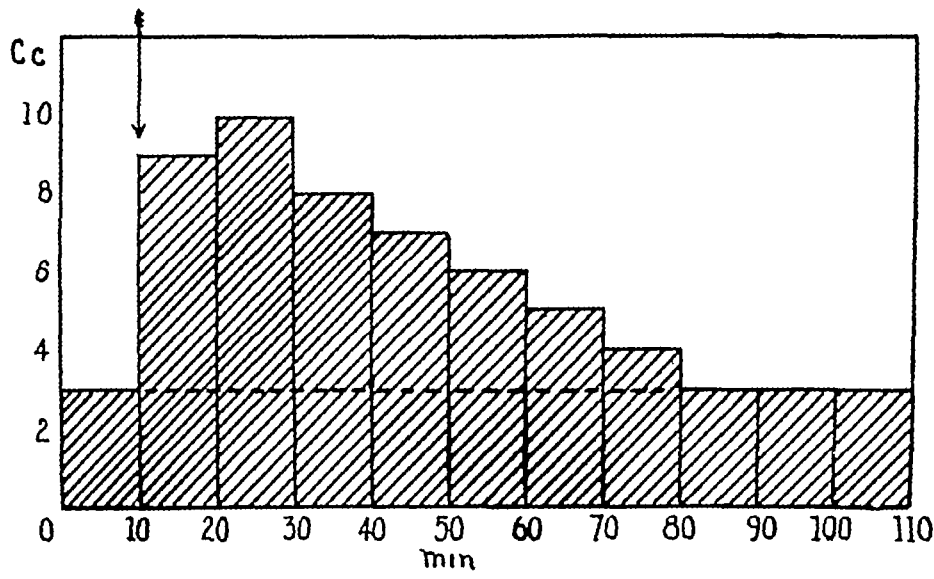


Chart 1—The acid stimulus to the flow of pancreatic juice is shown by the prompt increase in the rate of secretion from an intubated dog following the giving of 200 cc of 0.5 per cent hydrochloric acid by gavage (indicated by the arrow). The normal rate of flow of 3 cc for each ten minutes increased to 9 and then to 10 cc, and gradually dropped back to the normal rate after eighty minutes. The dog weighed 10 Kg.

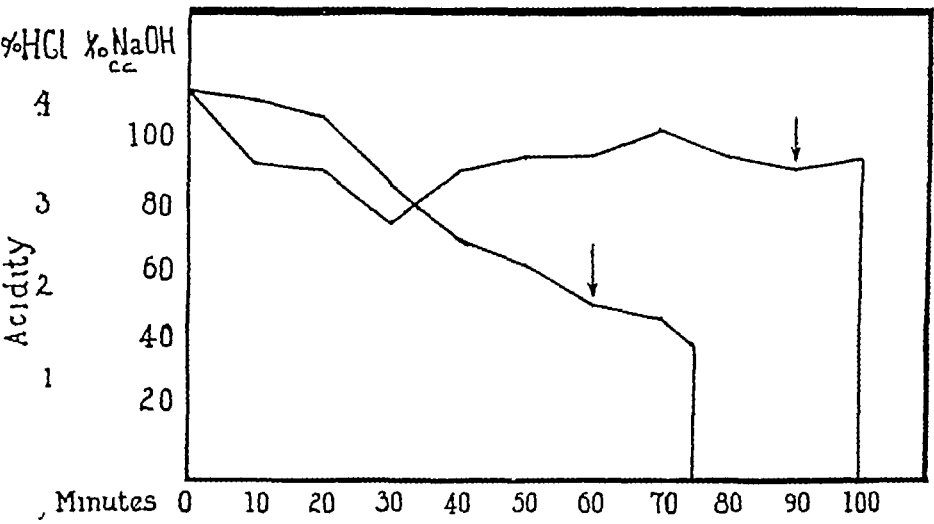


Chart 2—The failure of acid neutralization in the stomach after the giving of 200 cc of 0.5 per cent hydrochloric acid by gavage to a dog draining the entire pancreatic juice is shown in the upper curve. The titrations for "total" acid in successive aspirations remained high even after one and one-half hours. By contrast the prompt neutralization is shown in the lower curve of the same experiment in the same dog, but at a time when pancreatic juice was flowing back to the duodenum. The difference of twenty-five minutes in emptying time should also be noted (see text). The lower arrow indicates pancreatic juice flowing to the duodenum, the other arrow indicates pancreatic juice flowing to the outside.



by using the tendon of the biceps, to which is fastened a long strip of fascia. This is then passed under the neck by a special instrument, penetrating the capsule in two places, and is secured in a drill hole in the acromion. This gives a shinglelike action and anchors the head in the glenoid as well as to the acromion. The reefing feature has the advantage of plicating a heavy fascial band through the weak portion of the capsule, and the resulting fibrosis should leave a thick band encircling the neck and continuous with the suspension band. The operation was performed on four patients, and unsatisfactory results have not yet been seen. Ill effects from changing the biceps origin have not been noted.

[ED. NOTE.—It seems to us that the operation described does not offer any particular advantage over the method of direct fixation of the humeral head to the acromion by a fascial band. It appears considerably more complicated.]

*Operations on the Upper Extremity*—Steindler<sup>55</sup> analyzed the kinetics of the upper extremity and the various operative measures employed for the relief of paralysis of the shoulder, of the elbow, and of the wrist. Arthrodesis of the shoulder was performed in sixty-five patients because of paralysis of the deltoid. On the whole, the results were satisfactory, but not uniformly so. He found that the optimum functional position varied in children and adults, in adults, from 60 to 70 degrees. The author's operation for relief of paralysis of the flexor muscles of the elbow was performed on thirty patients, and the results have been satisfactory. The operation consisted of transplanting the common origin of the pronator teres, flexor carpi ulnaris, palmaris longus, and flexor carpi radialis muscles to a point higher up on the humerus. Forty-two operations were performed for relief of pronation contracture, mostly of the spastic type. The operation consisted of a resection of the pronator teres or pronator quadratus, and tendon transplantation of the pronator and flexor carpi ulnaris to the dorsum of the forearm. Paralysis of the wrist were treated by the operation of arthrodesis in fifty-four patients, and by tendon transplantation in thirty-four patients.

[ED. NOTE.—Steindler is a careful student and has had a great deal of experience in the treatment of paralytic conditions of the upper extremity which entitles his opinion to respect.]

*Loop Operation for Paralysis of Adductors of Thumb*—A loop operation for relief of paralysis of the adductor muscles of the thumb has been originated by Mayer.<sup>56</sup> This operation retains the essential features of the so-called pulley operation of Bunnell. It consists of passing

<sup>55</sup> Steindler, A. J. Bone & Joint Surg. 9:404 (July) 1927.  
<sup>56</sup> Mayer, L. Am. J. Surg. 2:456 (May) 1927.

flow back to the duodenum at will<sup>1</sup> The lower curve shows the normal drop in the acidity of the solution introduced into the stomach at a time when pancreatic juice was flowing back to the duodenum, the upper one, the absence of neutralization when it was draining to the outside

The experiments of Bolyreff<sup>2</sup> and of Migay<sup>3</sup> may well be referred to at this point These authors did not find any lowering in the acidity of hydrochloric acid solutions given dogs after ligation of the pancreatic ducts or after occlusion of the pylorus When the common bile duct or lower end of the esophagus was obstructed, neutralization proceeded normally They concluded from this that neither bile nor swallowed saliva are responsible for the phenomenon, but rather the reflux of pancreatic juice into the stomach

It is of special interest to note the behavior of "free" and of "combined" acid in these experiments, as shown in chart 3, which represents a typical instance Though the former value fell, the latter rose *pari passu*, so that the "total" acid remained the same In the normal, combined acid was not found,

*Titration of the Clear Fluid Obtained After Centrifugalization of the Contents of a Stomach Removed from Fasting Dogs Draining Pancreatic Juice Showing High Combined and Total Acid in Contrast to Those Removed from Dogs in Which the Juice was Flowing Back to the Duodenum*

Dog	Hours After Food	Day of Drainage	Free Acid	Combined Acid	Total Acid
51	8	4	40	103	143
54	9	2	24	88	112
63	6	1	38	90	128
63	36	3	0	78	78
50	4	2	18	64	82
53	6	2	10	86	96
52	18	2	0	40	40
59	6	{ 'Altercursive' fistula with pancreatic juice flowing back to the duodenum }	36	16	52
59	36		28	8	36
53	4		32	12	44

as the total and free acid were always the same, the fall in acidity affecting each equally This phenomenon may well be explained by the probable buffer action of the large amounts of intestinal contents regurgitated into the stomachs of these dogs which lose their total pancreatic juice The samples in the normal, on the contrary, were always clear The significance of this observation will be discussed

*The High Acidity of the Fasting Contents of Dogs Draining the Total Juice*—The contents of the stomach obtained from dogs after one or more days of drainage showed a much higher "total" acid than normal, in a few cases, it was three times as great (table) These specimens, too, showed a high value for the "combined" acid and contained a considerable amount of intestinal contents, as already mentioned

*The Regurgitation of Intestinal Contents into the Stomach*—In every instance in which the contents of the stomach were aspirated during the

6 Migay, F, quoted by Babkin, B P Diss, St Petersburg, 1909, Die äussere Sekretion der Verdauungstruse, 1914, p 382

the sublimus tendon of the ring finger through a loop formed by uniting the two ends of the free transplant of the sublimus tendon of the middle finger. The free end of the sublimus tendon of the ring finger is carried diagonally across the palm and drawn through a drill hole in the base of the proximal phalanx of the thumb. In the five patients on whom the operation was performed, there is excellent opposing action of the thumb and the usefulness of the hand has been much improved. The transplanted tendon can be felt to glide freely through the pulley loop.

*Reconstruction of the Crucial Ligaments of the Knee*—Horan<sup>57</sup> reported the results of reconstruction of the anterior crucial and internal lateral ligaments of the knee in eleven patients operated on by Alwyn Smith. The latter's modification of Hey Groves' operation (fascial substitution) was employed. All the patients were pensioners, and for this reason their responses were somewhat cautious, but with three exceptions good knees were reported. In one patient an arthrodiesis was performed five years after the original operation, and during this procedure a strong viable crucial ligament was found. The author concluded that the operation results in a joint capable of withstanding the stress and strain to which it is subjected in the course of an average life.

*Arthrodiesis of the Ankle*—For the condition of complete paralysis of the foot Straub<sup>58</sup> advocates the operation of pseudarthrosis of the ankle, including the tibio-astragalar, the subastragalar, the calcaneo-cuboid, and the astragaloscaphoid joints. To make the astragalus completely fill the space between the malleoli he splits the astragalus in the mid-sagittal plane, after removing the cartilaginous surfaces, and inserts a disk of bone cut from the anterior pole of the head of the astragalus. This separates the two halves of the astragalus and forces the outer surfaces of the halves against the inner surfaces of the malleoli.

*Etiology of Claw Foot*—Royce<sup>59</sup> made a study of the etiology of claw foot and concluded that the primary condition is a weakness of the gastrocnemius muscle, with a compensatory increase in the function of the tibialis posterior muscle. Proceeding on this theory, he suggested that the logical treatment is transplantation of the tibialis posterior tendon into the gastrocnemius muscle. He performed this operation on nine patients, with satisfactory results.

*Reproduction of a Metacarpal Bone by a Bone Graft*—Following excision of the entire fifth metacarpal bone Fowler<sup>60</sup> succeeded in replacing it by grafting an autogenous transplant from the tibia. The

57 Horan, Maurice Brit J Surg 14 569 (April) 1927  
58 Straub, G F Surg Gynec Obst 44 675 (May) 1927  
59 Royce, N D J Bone & Joint Surg 9 465 (July) 1927  
60 Fowler, Andrew Brit J Surg 14 675 (April) 1927

drainage of the total pancreatic juice, a good deal of admixed material was found. When drainage had occurred for three or four days, the specimen was thick and brownish, and by its fecal odor it betrayed its origin in the lower ileum. Autopsy in each case showed an intact gastro-intestinal tract without evidence of gastrocolic or ileogastric fistula. It was obvious that the material in the stomach was regurgitated intestinal contents, such as are never found in the stomach under normal conditions. Centrifugalization always yielded three layers. The upper layer was grayish and proved to be neutral fat, the lower one was dark brown or black, its nature was undetermined, and there was a more or less clear fluid between the two. Titration of this fluid always showed a high content of acid.

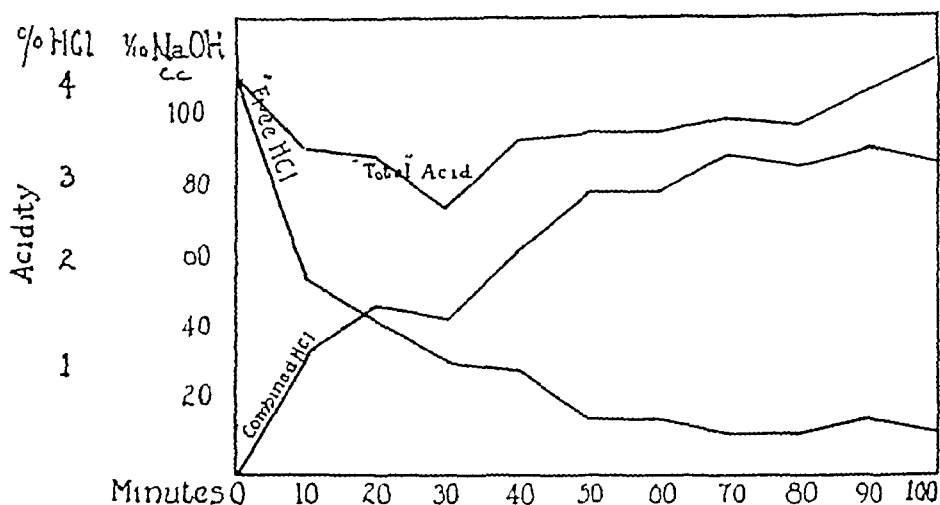


Chart 3—The behavior of "free" and "combined" acid in titration of aspirated samples after the giving of 200 cc of 0.5 per cent of hydrochloric acid solution to a dog draining the total pancreatic juice. After the free acid decreased, the combined acid increased so that the "total" acid was always the same. The aspirated samples always contained much regurgitated intestinal contents which probably accounted for this (see text).

#### COMMENT

The observations herein recorded throw considerable light on the nature of the severe gastro-intestinal upset which follows drainage of the total pancreatic secretion. In brief, they show that the contents of the stomach of such animals are abnormally acid, and, moreover, that there is a failure of neutralization to occur when acid solutions are introduced into their stomachs, though an intense flow of pancreatic juice is always provoked thereby. Finally, the constant finding of intestinal contents in the stomach of these animals shows that regurgitation occurred regularly.

The first inference from these observations was that I was dealing with a condition whereby some mechanism for the regulation of gastric

distal end of the graft was rounded and its proximal end implanted firmly in the carpus. Now after two and one-half years, he reports that nearly perfect function was present.

#### FRACTURES

*Metal Aids in the Treatment of Fractures*—Rossi,<sup>61</sup> from a study

of twenty-nine patients with fractures of the long bones, treated by internal metal fixation, drew the following conclusions: 1. In compound fractures of long bones, osteosynthesis with metallic means of direct fixation of the fragments furnishes, in many cases, a useful and necessary accompaniment either directly or after an immediate and careful cleansing of the wound. Open postoperative treatment of the wounds of compound fractures, if well immobilized, is not incompatible with the presence of metallic material. 2. When in simple fractures of long bones the roentgenograms reveal that the ordinary methods of reduction and fixation are not likely to obtain satisfactory reposition of the bones, early osteosynthesis represents the only method of treatment which is capable of giving perfect correction. Since the purpose of osteosynthesis is to secure exact temporary retention of the fragments during the period of consolidation, it must be strong enough to overcome the action of the muscles. The method of internal fixation should be simple, and capable of application with simple technique. 3. In the choice of the means of internal fixation, good judgment must be exercised. The site and accessibility of the fracture should be considered and the advisability of leaving the means of synthesis in the tissues. 4. While in compound fractures as well as in simple fractures foreign material such as metallic wire may be left in the tissues, it is necessary to remove the plates in compound fractures, and it is better to remove them when the consolidation is satisfactory in subcutaneous fractures, especially in sites like the tibia.

*Nerve Injuries Complicating Colles' Fracture*—Nerve injuries com-

plicating Colles' fracture are generally considered uncommon, but Turner<sup>62</sup> expressed the opinion that this is not the case. He found evidence of nerve involvement in several patients and was led to the belief that only on this basis can the so-called trophoneuroses of the hand that occasionally develop after Colles' fracture be explained. The author's views may be summarized as follows. The dorsal branch of the ulnar nerve lies over the ulnar head and often comes in close approximation to a fracture there. At the same level, or more distalward, lies the volar branch of the ulnar. The median nerve passes through the same region, but it is usually separated from the fracture site by the flexor pollicis longus and

61 Rossi, Aurelio. *Chir d org di Movimento* 10 486 (April) 1926.  
62 Turner, H. *Arch f klin Chir* 128 422, 1924.

acidity was interfered with, and the second one, that the alkaline pancreatic juice was responsible. The intense regurgitation of intestinal contents into the stomach, contents even from the lower part of the ileum, pointed to an attempt on the part of the body to compensate for the missing pancreatic juice, indeed, by its buffer action, it did exert some neutralizing effect (chart 3). Analysis of the evidence of others, finally seemed also to point to the existence of this mechanism and to its importance in the relationship between stomach and duodenum, both normally and in certain pathologic conditions.

That the level of gastric acidity is actually regulated by some neutralizing agent rather than by variations in the secretory activity of the gastric glands is based on the fact that pure gastric juice is always secreted at a much higher acidity than is ordinarily found in the contents of the stomach even after a test meal. Pavlov was the first to maintain, on the basis of his own observations, that the gastric glands secrete a juice of a constant and rather high acidity of about 0.5 per cent hydrochloric acid, or, in terms of titration values, of 140.<sup>7</sup> More recently, Carlson,<sup>8</sup> though questioning the truth of Pavlov's contention, in observing two patients with esophageal stricture and gastric fistula found that the actively secreted juice is always of a constant acidity close to 0.5 per cent hydrochloric acid. Rehfuess and Hawk reported evidence to show that human beings secrete gastric juice of a constant and high acidity,<sup>9</sup> and Hollander,<sup>10</sup> by experimentation on dogs, has shown that the actively flowing secretion from a Pavlov pouch is of a high acidity which after the injection of histamine equals a  $p_H$  of 0.92, or greater than 0.5 per cent hydrochloric acid. The much lower figures obtained in normal stomach contents must obviously be due to the existence of some neutralizing mechanism. Such a mechanism, furthermore, has been strikingly demonstrated by Kahn and Yaure.<sup>11</sup> These authors, using  $p_H$  as a measure of acidity, gave test meals to dogs with a Pavlov pouch and simultaneously studied the contents of the main stomach as well as the pure juice flowing from the isolated pouch. Whereas the former varied considerably and never was more acid than  $p_H$  1.9, the pure juice was secreted at the high and constant acidity of  $p_H$  1.1.

This regulation may occur, of course, by the diluting action of swallowed saliva, mucus, bile or pyloric secretions, and this mechanism

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7 Pavlov, J. P. *The work of the Digestive Glands*, London: C. Griffin & Company, 1910, p. 32.

8 Carlson, A. J. *Am. J. Physiol.* **33**: 248, 1915.

9 Rehfuess, M. E., and Hawk, P. B. *Gastro-Intestinal Studies*. *J. A. M. A.* **63**: 2088 (Dec. 12) 1914.

10 Hollander, F. *Proc. Am. Soc. Biol. Chem., J. Biol. Chem.* **74**: 23, 1927.

11 Kahn, J., and Yaure, G. *Arch. f. d. ges. Physiol.* **206**: 119, 1924.

the pronator quadratus muscles. The volar interosseous nerve runs more deeply and is usually in no danger of injury. The radial nerve may sometimes be injured, but the dorsal interosseous nerve is least favorably situated to escape injury. It lies in direct contact with the dorsal surface of the distal end of the radius. Careful study in the first few days of each patient with Colles' fracture will, according to the author, often reveal evidence of a nerve injury. The usual signs are excessive perspiration in the palm, hyperesthesia on the palmar side of the carpal bones, hyperesthesia of the thenar eminence, and pain over the ulnar nerve distribution, particularly when the ulnar styloid has been torn off. Bruising or overstretching are considered common, but are overlooked because the attention of the surgeon is focused on the change in the bone. The most serious changes occur in injuries of the dorsal interosseous nerve. Here after a few days, sometimes only after a week or more, a hard edema appears on the dorsum of the hand, extending to the middle third of the forearm and distalward to the second phalanges of the four fingers. The skin is glossy and usually reddened. Stiffness of the fingers soon follows, with limitation of motion both actively and passively. If one attempts motion with force, there is sharp pain in the fingers and forearm. An extension contracture of the fingers develops with slight flexion at the proximal interphalangeal joints. Motion also becomes decreased at the wrist joint. Later an actual swelling of the proximal interphalangeal joints may develop. The condition remains indefinitely without any change. Roentgen-ray examination of the hand shows increased radiability and haziness of the lower end of the radius, the third and fourth metacarpal bones, and less in the second and fifth, and there is not any change in the first metacarpal bone. The changes are seen to be less marked as the examination proceeds up the forearm. The essential changes are osteoporosis and a disintegration of the internal architecture of the bone. Two cases are reported in which the changes mentioned occurred. In the second case an exploratory operation was performed on the dorsal interosseous nerve. The nerve in the region of injury was found to be somewhat spindle-shaped and suggested. A slight improvement followed the exploratory operation, with less edema and less stiffness of the fingers. The author concluded that this condition is a trophoneurosis produced originally by trauma and attributable to an injury of the dorsal interosseous nerve. He added as proof three more cases in each of which the patient was bitten by a cat over the course of the dorsal interosseous nerve, and in which the same neurologic disturbances occurred as in the cases of Colles' fracture. The author did not suggest any treatment for the condition, although slight improvement did occur in one case following operation.





100 diastolic) and cardiac hypertrophy. None of these factors, however, except the anemia, can be said to have influenced the hyperthyroidism other than indirectly. These five patients, however, were suffering from conditions which placed the heart under a continuous abnormal strain. Of the eight cases, six were classed by Rienhoff as typical instances of exophthalmic hypertrophy, although the presence of a capsule had influenced the pathologic laboratory to designate them as mixed colloid and fetal adenomas. The other two patients showed more than average hypertrophy and hyperplasia.

Of the ten patients who were given iodine in the hospital, three showed marked improvement, three slight improvement and four none. Two of the patients who were not helped by iodine died, one, whose basal metabolic rate was 60 per cent above normal, had marked anemia (hemoglobin content 55 per cent, red blood cell count 3,068,000), blood pressure of 170 systolic and 60 diastolic and a large cystic goiter in which cellular hypertrophy and hyperplasia of the small acinar type were demonstrable at operation, the other, whose basal metabolic rate was 40 and 37 per cent above normal, had auricular fibrillation and a goiter of twenty-four years' duration, which showed typical cellular hypertrophy and hyperplasia with areas of degeneration. One of the patients who was not benefited by iodine became restless and had a much higher basal metabolic rate, probably as a result of psychic disturbance, in the other patient, the basal metabolic rate rose from 25 to 31 per cent above normal in ten days, and the iodine was discontinued. The three patients who improved markedly under treatment with iodine showed characteristic cellular hypertrophy and hyperplasia which had undergone an iodine remission. In two of the three patients who showed only slight improvement under treatment with iodine, encapsulated areas of cellular hypertrophy and hyperplasia were demonstrated. The effect of iodine was much less striking and less frequent in the older group than in the younger group.

The average increase in the basal metabolic rate was 39.5 per cent above normal, the average blood pressure was 162 systolic and 80 diastolic.

In the older group an appreciable secondary anemia was not uncommon, the average hemoglobin content being 66 per cent. This factor serves<sup>3</sup> at least to increase the load of the heart as well as to raise the basal metabolic rate.<sup>4</sup>

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<sup>3</sup> Blalock, Alfred, and Harrison, Tinsley R. Unpublished Observations on the Cardiac Output in Anaemia, quoted by Harrison and Leonard. *J Clin Investigation* **3** 1, 1926.

<sup>4</sup> Tompkins, E. H., Brittingham, H. H., and Drinker, C. K. Basal Metabolism in Anaemia, *Arch Int Med* **23** 441 (April) 1919.

[ED NOTE—The article by Turner was published in 1924, but was overlooked at that time and so not included in the Report of Progress in Orthopedic Surgery. Only recently was our attention called to it, but it appeared significant, and for this reason it is abstracted in this report. We have observed several patients who unaccountably developed painful stiff hands after Colles' fracture, and Turner's theory affords a plausible explanation.]

*Late Results of Fractures of Long Bones*—Walker<sup>63</sup> has continued with his studies of the late results of gunshot and other fractures among the American combatants in the World War. He reviewed the results in 4,647 fractures of the femur. He compared the results in veterans who applied to the bureau for relief twelve, eighteen, twenty-four, thirty, and thirty-eight months after injury. After a period of four years, the examination showed an improvement in disability rating of 86 per cent in the twelve months group, 77 per cent in the eighteen months group, 62 per cent in the twenty-four months group, 45 per cent in the thirty months group, and only 14 per cent in the thirty-six months group.

*Epiphyseal Separation of the Ischium*—Schoolfield<sup>64</sup> described the rare case of a patient with epiphyseal separation of the ischium. Roentgen-ray examination showed an inward displacement with considerable encroachment on the pelvic cavity, the ilium and pubes apparently remaining in normal relationship. There was a defect in the acetabulum. The head and neck of the femur showed changes characteristic of Legg-Calve's disease. A perfect reduction was finally obtained following two manipulations and fixation of the hip in a position of wide abduction.

*Fractures of the Knee*—Zanoli<sup>65</sup> made a study of fractures in the region of the knee, excluding fractures of the patella, using the material of the Rizzoli Institute. Between the years 1899 and 1922, thirty-four patients with such fractures were treated of a total of 1,864 fractures, thus making a proportion of 1.23 per cent. Interarticular fractures of both the lower end of the femur and the upper end of the tibia were included. From a study of the results the writer concluded that conservative treatment, using the traction apparatus of Zuppinger until replacement of the fragments is obtained and then immobilization in a plaster casing, is the method of choice.

[ED NOTE—We do not know of any more difficult fracture problem than that represented by some of the interarticular fractures of the upper end of the tibia. The entire joint surface may be disrupted, and

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63 Walker, J. B. U. S. Vet. Bur. M. Bull. 3: 651 (July) 1927.

64 Schoolfield, B. L. J. Bone & Joint Surg. 9: 498 (July) 1927.

65 Zanoli, R. Chir. d. org. di Movimento 10: 463 (April) 1926.

oped auricular fibrillation with the thyrotoxicosis. This was the only case in the younger group in which auricular fibrillation was noted, whereas in the older patients, whose hearts were less able to stand the strain, fibrillation occurred in eight cases. The fact that the cardiac symptoms always cleared up, or at least were greatly ameliorated, after thyroidectomy is, apparently, an argument against any cardiac damage resulting from the thyrotoxicosis. At any rate, it proves that the condition of these hearts (in this series all to be found in the older group) may change from auricular fibrillation and myocardial insufficiency to normal rhythm and compensation when the metabolism has been lowered and presumably the thyrotoxicosis has been removed.

Christian<sup>9</sup> cites two instances of cardiac decompensation which occurred when the basal metabolic rate in long-standing cases of myxedema was brought up toward normal by the use of desiccated thyroid gland. The heart in these cases was able to function satisfactorily on a low plane of metabolic activity, but was unable to stand the added burden brought about by an increase in the metabolic rate. In like manner one may explain the satisfactory therapeutic results of subtotal thyroidectomy reported by Hamilton<sup>10</sup> in two cases of cardiac decompensation with nodular goiter, without hyperthyroidism. In these cases, compensation was established when, presumably, the metabolic rate was lowered from normal to subnormal, and the question of thyrotoxicosis did not enter in.

Robinson and Burwell,<sup>11</sup> studying a case of hyperthyroidism, find the cardiac output greatly increased, and believe this to be an evidence of abnormal heart strain. Similar observations are reported by Liljestrand and Stenstrom<sup>12</sup> who report observations on eleven cases of exophthalmic goiter in which there was a cardiac output of 80 per cent above normal (female) and 100 per cent above normal (male). Harrison and Leonard<sup>13</sup> believe, from their study of cardiac decompensation in dogs, that this condition is associated with an increased cardiac output, and Robinson<sup>14</sup> reports confirmatory observations in

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9 Christian, H. A. *The Heart and Its Management in Myxedema*, Rhode Island M. J. **8** 109, 1925.

10 Hamilton, Burton E. *The Heart in Toxic Thyroid States*, S. Clin. N. Amer. **4** 1411, 1924.

11 Robinson, G. C., and Burwell, C. S. Personal communications, quoted by Harrison, T. R., and Leonard, B. W. *J. Clin. Investigation* **3** 1, 1926.

12 Liljestrand, G., and Stenstrom, N. *Circulation in Exophthalmic Goiter*, *Acta med. Scandinav.* **63** 99, 1925, abstr., *J. A. M. A.* **86** 456 (Feb. 6) 1926.

13 Harrison, T. R., and Leonard, B. W. *The Effect of Digitalis on the Cardiac Output of Dogs and Its Bearing on the Action of the Drug in Heart Disease*, *J. Clin. Investigation* **3** 1, 1926.

14 Robinson, G. C. *The Disturbances of Cardiac Function Leading to Heart Failure*, *South. M. J.* **20** 222, 1926.

injuries of the semilunar cartilages and of the crucial and lateral ligaments are frequent accompaniments. The only chance of restoring function in such a knee lies in early operative treatment. There is such wide variation in the damage caused by these fractures that it is impossible with fairness to group them in one class and conclude, as the author of the foregoing article has done, that nonoperative treatment is the method of choice.]

## RESEARCH

*Influence of Diet on Healing of Wounds*—Herrmannsdorfer,<sup>66</sup> who in collaboration with Sauerbruch previously studied the effects of diet on patients with surgical tuberculosis, has now gathered together his observations bearing on the effects of diet on wounds and infections. He found important differences between the metabolism of healthy persons and that of persons with infected wounds. The reaction of infected wounds is acid, and the more severe the infection the greater the acidity. The alkali reserves of the blood are lowered. He stated that it is possible by suitable diet to influence the acidity of the wound and that this can be demonstrated. With an acid diet the weight of the body is in balance, the wound shrinks, the secretion decreases, and the bacteria diminish, in both variety and number. On the other hand, with an alkaline diet the weight of the body increases and the appearance of the wound changes for the worse. The granulations swell, the wound secretion becomes greater in amount, a pseudodiphtheritic membrane spreads over the surface, and the bacteria are increased in number and in variety. The writer expressed the belief that the experiments clearly show that the living tissues are subject to great variation in chemical composition and that these changes have an influence in determining whether bacteria will find them favorable or unfavorable culture mediums.

[ED. NOTE—We report this article with reserve, hoping that it may stimulate others to repeat the experiments and either confirm or disprove Herrmannsdorfer's observations.]

*Joint Fluid Ferments*—Abderhalden and others have shown that the juices of certain organs have specific reactions resembling those of ferments in that they act only on peptones obtained from those organs. Hempel<sup>67</sup> tested synovial fluid on joint cartilage, using Abderhalden's microtechnic. In six of twenty-two patients specific ferments were demonstrated, in seven patients the results were negative, and in the remaining patients the joint fluid was not of a character to permit optical examination. In four of the six positive tests, the cartilage was distinctly affected. The reaction is said to be so exact that a lesion of

66 Herrmannsdorfer, A. *Deutsche Ztschr. f. Chir.* 200:534, 1927.

67 Hempel, C. *Zentralbl. f. Chir.* 54:2377, 1927.

## CONCLUSIONS

1 In a series of thirty-two cases designated as instances of nodular goiter with hyperthyroidism, sections from the gland in every instance revealed areas of hypertrophy and hyperplasia of the thyroid epithelium

2 Patients in the age group below 45 years show pathologic changes closely simulating those of exophthalmic goiter, and their disease may be classified as mild, pure hyperthyroidism

3 Patients in the age group above 45 years nearly all present morbid conditions such as heart failure, hypertension, obesity or anemia, which, when augmented by more or less slight hyperthyroidism, present a serious clinical picture

4 When one considers the various factors which combine to produce the clinical picture, a close parallelism is seen between the degree of hypertrophy and hyperplasia of the thyroid epithelium and that of thyrotoxicosis

5 These cases of nodular goiter with hyperthyroidism seem to differ from cases of exophthalmic goiter chiefly in the degree of thyrotoxicosis, and occur mainly in elderly persons who are suffering also from other conditions which disturb their circulatory mechanism

6 These facts seem to be in accord with Rienhoff's hypothesis, that 92 per cent of nodules in the thyroid gland are the result of a long-standing or frequently recurring overactivity of the thyroid gland

the cartilage which is invisible macroscopically may give a positive result Hempel also pointed out the close relationship between the blood and the joint fluid, as shown by the similarity in the contents of both fluids

*Healing in Injuries of the Carpal Scaphoid* —Johnson<sup>68</sup> carried out a series of experiments on animals to demonstrate the reparative processes after injury in the short cancellous aperiosteal type of bone, such as the carpal scaphoid. The same operative procedure was performed in each of a series of adult dogs. In one forepaw the scaphoid was fractured with an osteotome, in the scaphoid on the opposite side a deep defect was created with a small drill. At the same time, in the corresponding radius, an osteotomy was performed or a defect made in the lower third of the bone. The dogs were then killed at various time intervals up to six weeks. From a study of the specimens thus obtained the author drew the following conclusions: 1 Bone repair takes place in the scaphoid in exactly the same manner as in the medulla of the diaphyses, but the process is not as active or as extensive. 2 There is no interference with vascularity of the fragments which would cause necrosis, delayed union, or nonunion. 3 In these experiments approximation of fragments was so close that mobility or displacement did not play any part in retarding union. 4 Lytic action of the synovial fluid was not observed. 5 Lack of all periosteal callus is a large factor in causing slower union. 6 Fractured hyaline cartilage heals by fibrous tissue, and adjacent but undamaged hyaline cartilage also often undergoes fibrous change. This gives rise to permanent changes of the articulating surfaces and is probably the element most responsible for poor functional results seen clinically in these fractures. 7 All bones of this cancellous type healed more slowly than the long bones. This is due largely to the lack of subperiosteal callus formation, but it is also due, in part, to the cancellous reaction being less extensive and less active than is the medullary response in the diaphysis.

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68 Johnson, R. W., Jr. J Bone & Joint Surg 9 482 (July) 1927

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juice secreted and in the degree of acidity were found in normal persons, although repeated examinations on the same person varied but slightly. Here, again, a normal curve of secretion cannot be constructed.

#### USE OF HISTAMINE

Previous to the publication of these papers, I had decided on histamine, or one of its compounds, as a standard stimulus for secretion of gastric juice. The ability of this compound to stimulate gastric secretion was studied by Popielski,<sup>2</sup> who showed, by section of the vagi, that the drug acts directly on the gland cell. The clinical use of histamine in the study of gastric secretion was advocated by Carnot and Libert,<sup>3</sup> and has since been resorted to mostly in differentiating types of achylia. This drug was preferred because it can be procured in a stable form and is administered by hypodermic injection, so that the factor of dilution of gastric secretion by the stimulating substance is avoided. The amount of fluid withdrawn from the stomach every ten minutes represents, then, pure gastric juice, minus the amount lost during that time through the pylorus plus the amount added to the gastric contents by the regurgitation of duodenal fluid through the pylorus. This factor of regurgitation will be discussed later. The amounts gained this way, or lost by escape through the pylorus, cannot be measured accurately, and what is assumed to be the amount of gastric juice secreted is really the resultant of the three phenomena of secretion, regurgitation and loss through the pylorus.

The curve obtained after intramuscular injection of 1 mg of histamine into the normal dog is shown in chart 1. The stomach was emptied by thorough aspiration every ten minutes and 10 cc titrated with tenth-normal sodium hydroxide, using Topfer's reagent as an indicator for free hydrochloric acid and phenolphthalein as an indicator for total acidity. These results are expressed in the amount of tenth-normal sodium hydroxide necessary to neutralize 100 cc of gastric juice, because this method is the one in common use. The effect of the drug is noticed in the first aspiration made, and the highest degree of acidity is reached from thirty to forty minutes after injection. This is equivalent to 0.45 per cent of hydrochloric acid, slightly less than the degree of acidity of pure gastric juice as secreted. Variations from the foregoing curve were not marked in normal dogs, in no case being more than 10 during the first sixty minutes of the examination. The amount of secretion during a ten minute period for the first sixty minutes varied from 10 to 20 cc, occasionally more, early in the examination, while the lesser amounts were recovered toward the end. Although this method

2 Popielski, L. *Pflüger's Arch f d ges Physiol* **178** 215, 1920

3 Carnot, P, and Libert, E. *Médecine* **6** 757, 1924

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juice is a constant occurrence in the resting, as well as in the active, stomach was shown by Spencer and others,<sup>6</sup> who found trypsin in the gastric contents, the amount of the enzyme varying inversely with the degree of acidity. The common error has been to regard the presence of bile in the stomach as an index of regurgitation. Bile is not produced in response to high gastric acidity and is emptied into the duodenum in spurts of small amounts at a time, depending on the tonus of the duodenal musculature. On the other hand, the pancreatic juice is secreted in direct response to gastric acidity, and one of its functions is to neutralize the latter before the acid reaches the much more sensitive intestinal mucosa. It also finds its way into the duodenum by two openings, one entirely independent of the opening of the bile duct and

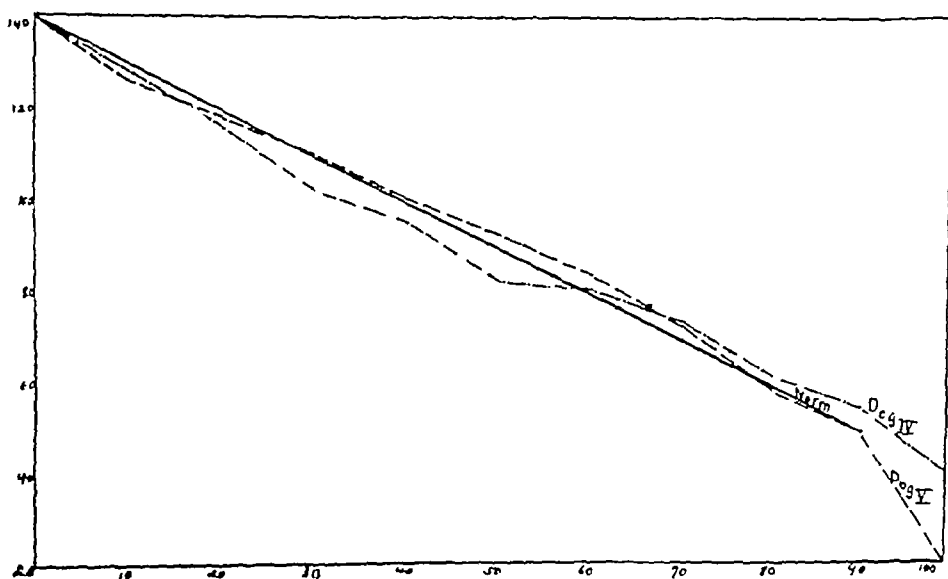


Chart 2—Curve of decrease in gastric acidity after introduction of 200 cc of 0.5 per cent hydrochloric acid into stomachs of normal dogs. The heavy black line is the average normal curve, the broken lines show the slight deviation from this norm of two dogs.

the other separated from it in a large percentage of cases. The whole mechanism, then, is one of protecting the intestinal mucosa from the acid. In regurgitation experiments made by Elman<sup>6</sup> on dogs with complete duodenal fistulas, the gastric acidity was reduced slightly, and then by intestinal juices brought to the stomach from low in the intestinal tract by antiperistalsis. The prepylorus, pylorus and first portion of the duodenum can be regarded as a single organ the function of which is that of a mixing chamber. The result of this activity is illustrated in chart 2, following the introduction of 200 cc of 0.5 per cent hydrochloric acid

<sup>6</sup> Spencer W. H., Meyer, Rehfuess M. E., and Hawk P. B. *Am. J. Physiol.* **39**: 459, 1915.

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of the extrinsic nerves on the motor activity of the stomach. There has been considerable difference in the results obtained, as may be seen by comparing the recent work of Hughson<sup>7</sup>, McCrae, McSwiney and Stopford<sup>8</sup> and Latarjet<sup>9</sup>. The latter found a marked increase in the emptying time following section of the branches of the vagi in the abdomen. McCrae and his co-workers concluded that with the exception of a temporary change shortly after the operation, the only variation in motor function which occurred was some reduction in the initial emptying time. Hughson, using a simpler opaque mixture introduced directly into the stomach, found a constant definite decrease in the emptying time; he also found that following section of the vagi or its branches, reflex spasm of the pylorus could not be produced later, a phenomenon which can always be brought about in an animal with intact vagi. In other words, in these animals there resulted a hypotonus of the pylorus which allowed increased patency of the pyloric lumen.

Section of the branches of the nerve entering the stomach has been reported clinically by Wertheimer and Latarjet,<sup>10</sup> who performed this procedure on twelve patients; they sometimes combined it with some other operation on the stomach. In these cases, the preoperative conditions and function of the stomach are not always clear, and the postoperative examinations as reported are not conclusive. None of these patients had peptic ulcers. Schiassi<sup>11</sup> advocates this method of treatment for patients with gastric and duodenal ulcer, either alone or accompanied by one of the operations usually performed; he does not offer any clinical or experimental evidence, however, on which to base his procedure.

The experiments described were carried out by me during the course of an investigation of the physiologic end-results after operative treatment for peptic ulcer. They were carried out on dogs which were first subjected to the two methods of examination already described. Then the nerves supplying the stomach were sectioned in one of three following ways: 1. Section was made intrathoracically, because by this method any change due to peritoneal irritation was avoided and because the vagus branches only were sectioned. 2. The branches were sectioned in the abdomen, the two large trunks being severed as they came through the diaphragm, one on the anterior and the other on the posterior surface. The smaller branches were cut to make certain of

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7 Hughson, W. Effect of Vagus Neurotomy on Pyloric Sphincter, *J A M A* **88** 1072 (April 2) 1927.

8 McCrae, E. D., McSwiney, B. A., and Stopford, J. S. B. *Quart J Exper Physiol* **16** 195, 1926, *ibid* **15** 201, 1925.

9 Latarjet, A. *Bull Acad de med, Paris* **87** 861, 1922.

10 Wertheimer, P., and Latarjet, A. *Presse méd* **31** 993, 1923.

11 Schiassi, B. *Ann Surg* **81** 939 1925.

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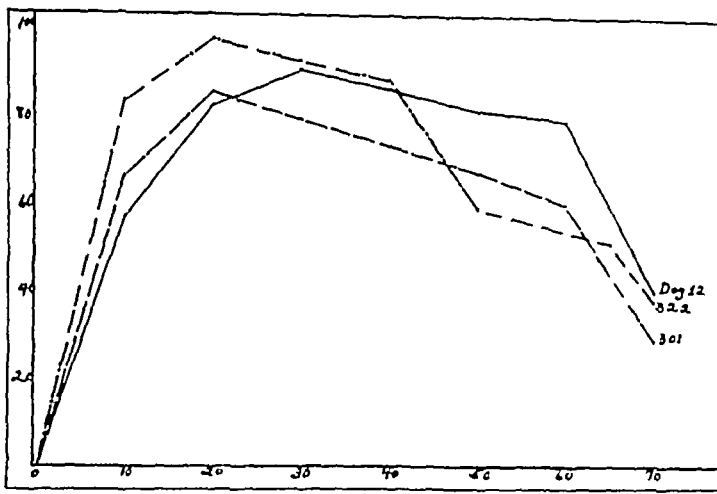


Chart 3—Curve of secretion after injection of histamine, following section of vagi intrathoracically

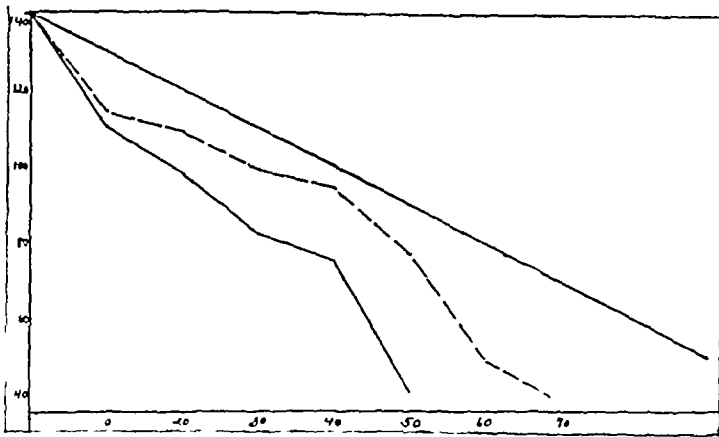


Chart 4—Neutralization of gastric contents after introduction of 0.5 per cent hydrochloric acid. Results obtained in two cases following section of the vagi intrathoracically as compared with the average normal curve, which is represented by the heavy black line

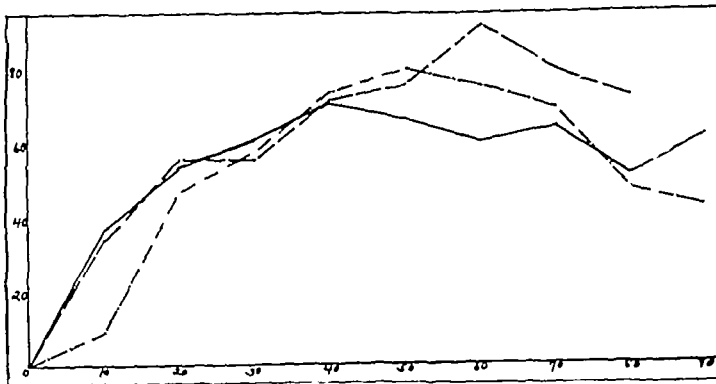


Chart 5—Curve of secretion of hydrochloric acid after injection of histamine obtained in three dogs after section of the vagi intraperitoneally

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## PYLOROPLASTY

The Finney pyloroplasty was performed on another series of dogs. The curves obtained from one of these animals are seen in charts 9 and 10. All the animals reacted in a manner similar to that of the one used as an illustration. After the administration of histamine, the hydrochloric acid secreted in the gastric juice does not reach 90 (0.32 per cent). The reason for this is probably the same as that mentioned, the regurgitation of alkaline pancreatic juice to neutralize the acid as it is secreted. This regurgitation is most marked after the introduction of 200 cc. of 0.5 per cent hydrochloric acid into the stomach. Chart 10 shows the curve obtained one month after operation. There is a uniform sharp decrease in acidity, with shortening of the emptying time to fifty and sixty minutes. A large stoma with no control of the sphincter replaces the natural opening. As the acid comes in contact with the duodenal mucosa, the pancreatic juice is secreted and immediately enters the stomach, where the acid is neutralized. With this large opening and free access between the duodenum and the stomach, this neutralization takes place more quickly, and the plotted curve is much more distant from the norm than is the case with any of the other procedures. As the optimum reaction is reached sooner, the stomach empties in much less time.

## COMMENT

In the many different methods of gastric analysis, the phenomenon of regurgitation is not considered. A reading of titratable acidity or alkalinity in the stomach at any given time is the mean of two opposing forces, secretion of gastric juice and its neutralization by regurgitant duodenal fluid, which owes most of its effectiveness to the highly alkaline pancreatic juice. The regurgitation of the latter fluid into the stomach is a constant occurrence in the resting as well as in the digesting stomach, a fact which has been corroborated in many ways. The duodenum, pylorus and prepylorus might well be considered a single organ, for they have one important function in common, that of a mixing chamber in which the chemical reaction of their contents is adjusted to the optimum which can be tolerated by the intestines. This phenomenon, then, is of the utmost importance in the process of digestion, and a test of the stomach's function resolves itself into a test of this function of neutralization. To measure this accurately, a direct application of the phenomenon described by Boldyreff is advocated, *i. e.*, the introduction of 200 cc. of 0.5 per cent hydrochloric acid into the stomach, with examination of the contents every ten minutes. From observations made during the examination of many dogs by this method, a normal curve is constructed, from which there are minor individual deviations. Following the various operative procedures, the curves



of histamine is preferable, because the psychic phase of secretion is avoided by subcutaneous administration, a standard amount of a known substance is given, the factor of dilution is avoided, and one is nearer to recovering pure gastric juice, the only dilution being the regurgitated duodenal fluid

The results reported are those obtained on dogs, the results of clinical application will be reported at a later date

#### CONCLUSIONS

1 Regurgitation of duodenal fluid into the stomach is a constant occurrence The important constituent of this fluid is the pancreatic juice

2 Neutralization of gastric acidity by this regurgitating fluid is an important part of digestion

3 This rate of neutralization can be measured accurately, and can be made a part of every gastro-intestinal examination

4 Rapid decrease in acidity is the ideal result following operation for ulcer of the stomach This is brought about by the large stoma resulting either from resection or from pyloroplasty If the stoma is small when ordinary gastro-enterostomy is performed, the necessary amount of regurgitation does not occur

5 Intrathoracic or intraperitoneal vagotomy results in decreased tonicity of the pylorus This is reflected in the more rapid emptying and the decrease of gastric acidity



ephedrine by mouth and to epinephrine subcutaneously. There was recurrent urticaria for several days. Mild desquamation occurred, most extensively at the site of cellulitis, from March 10 for about four days. The area of cellulitis was marked for a time by a brownish tint, but returned to normal. The toe healed completely, and the patient was discharged, well, on March 17, 1927.

Bacteriologic study was conducted as follows: saline was injected at the edge of the area of cellulitis on February 25 (the day after admission) and on February 26. It was withdrawn and cultured, but a growth was not obtained. On February 25, a throat culture showed approximately 5 per cent of hemolytic streptococci, several strains of which were isolated. Pure cultures of hemolytic streptococci were found in pus from the abrasion on the toe on February 26 and 27. The organisms from the toe and throat cultures were studied further, they proved to be short chained, gram-positive cocci, producing typical beta hemolysis in poured blood-agar plates. They did not ferment mannitol in ascitic fluid broth. Growth in broth was flocculent, but emulsion made from ascitic fluid agar slopes proved to be stable and were used for agglutination. Several strains of the throat and toe cultures agglutinated to the titer of a scarlatinal streptococcus antiserum prepared with Dick strain 25<sup>6</sup>. Flasks of Douglas broth were inoculated and in two to four days, the growth was passed through Berkefeld V filters, 0.5 per cent phenol was added and dilutions made for skin testing. Both the throat and toe strain filtrates in a dilution of 1:100 caused a sharp localized erythema when injected intracutaneously in doses of 0.1 cc in persons with a positive Dick reaction. We repeatedly obtained inhibition of erythema with the organism cultured from the toe, when the filtrate dose was mixed with 1 unit of scarlet fever antitoxin (Dochez type). Proper controls, with due account for dilution, were made in each case. The filtrate from strains isolated from the throat, however, produced an erythema not influenced by previous admixture with scarlet fever antitoxin, even when the unit erythema dose of filtrate (0.1 cc of 1:100 dilution) was combined with as high as 20 units of antitoxin. This observation was checked several times with different lots of antitoxin.

We feel that this definitely classifies the organism from the initial lesion on the toe as *Streptococcus scarlatinae*. By culture, agglutination and neutralization of the skin toxin which it produced, it fulfilled all criteria. We did not feel justified in attempting to reproduce the disease in man. The streptococcus isolated from the throat, however, failed to qualify either clinically, in view of the absence of angina, or serologically, in that the toxin which it produced was not neutralized by scarlet fever antitoxin. The production of a skin toxin not neutralized by standard scarlet fever antitoxin has been observed by Kirkbride and Wheeler<sup>7</sup> with streptococci from scarlet fever and from other sources also. Hence we consider that this patient had scarlet fever. The causative organism

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6 We are indebted to Dr. S. Bayne-Jones of the Department of Bacteriology for this agglutinating serum.

7 Kirkbride, Mary B., and Wheeler, Mary W. Studies of the Toxins of the Hemolytic Streptococci Associated with Scarlet Fever, *J. Immunol.* **11**: 477 (June) 1926, Further Observations on the Toxins of Hemolytic Streptococci, *J. Immunol.* **13**: 19 (Jan.) 1927.



# COLLAPSE FOLLOWING SUDDEN DECOMPRESSION OF THE DISTENDED ABDOMEN

A STUDY IN EXPERIMENTAL ASCITES \*

OWEN H WANGENSTEEN, M D

AND

HORACE G SCOTT, B A

MINNEAPOLIS

In tapping the abdomen of the patient with marked ascites, the necessity for caution in removing the fluid slowly is well known. To obviate the collapse of the patient consequent on the too rapid removal of the transudate, a Scultetus bandage or a binder is frequently placed around the abdomen at the start and is tightened as the fluid is removed. The same prudence in performing paracentesis of the pleural cavity is a matter of every-day practice. On consulting a large number of modern surgical texts, we have been unable to find a word of caution in this regard in the matter of incising the distended abdomen. In discussing the subject with several of our preceptors and colleagues, however, we find that most of them know of or have had personal experience with instances in which collapse followed directly on the sudden decompression of the distended abdomen by incision. The synopses of the records of two patients in whom this phenomenon occurred and who were observed in the surgical service at the University Hospital follow.

## REPORT OF CASES

CASE 1—A boy, aged 15, was admitted to the University Hospital, May 22, 1925, and was discharged, June 14, 1925.

About 5 p. m., on May 21, the patient was kicked in the lower left abdominal quadrant by a horse. He was knocked down and lay in a faint for about three minutes. When picked up by his mother, he complained of severe pain over the entire lower part of the abdomen.

At 3 p. m., on May 22, he was brought to the University Hospital. At this time he complained of pain on respiration above the left clavicle.

On examination, the boy was found to be well developed and well nourished. There was a slight cyanosis of the mucous membranes of the lips. He did not appear to be in great distress, but complained that movement caused him pain. The pulse was full and strong, the rate being about 90 beats a minute, the temperature was 98.8 and the respirations, 22, the systolic blood pressure was 124, diastolic, 82. Results of the examination of the chest were negative. The abdomen was moderately distended and exhibited "choc en retour." On palpation it was found uniformly tender. Dulness on percussion was demonstrated in the flanks. The midportion of the abdomen was tympanitic. Movable tympani could not be demonstrated. On auscultation of the abdomen, peristaltic movements were not heard. Rectal examination showed that bulging was present and that the region was moderately tender.

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\* From the Department of Surgery of the University of Minnesota.





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explanation of which is to be found in compression of the inferior vena cava with a diminished return of blood to the right side of the heart. He<sup>4</sup> also believed that excessive intra-abdominal pressures caused death by heart failure rather than by interfering with respiration. Thorington and Schmidt<sup>9</sup> (1923) too recorded the effects of an increase on blood pressure. They found that the changes in the general circulation were not constant, but usually a fall of from 5 to 10 mm of hemoglobin was observed in the arterial pressure when the ascites established inhibited the excretion of urine. Often after an initial fall the blood pressure was observed to rise to a point higher than it was originally when the intra-abdominal pressure was maintained at a pressure of 30 mm of hemoglobin (40.5 cm of water). Coombs<sup>6</sup> stated that an appreciable rise in carotid pressure was never obtained following the gradual introduction of fluid into the abdominal cavity, but in several instances, the removal of the fluid was accompanied by a distinct rise in arterial pressure.

We have failed, however, to find any reference to a study or investigation relative to the sudden release of increased intra-abdominal pressure on the arterial pressure. Believing that the collapse that occasionally follows the sudden decompression of a distended abdomen might be duplicated and elucidated in such an experiment, we have put it to experimental test. In this study of experimental ascites we have concerned ourselves with this issue only.

#### METHOD

An increased intra-abdominal pressure was established in twelve dogs by inserting a glass cannula with a flange into the peritoneal cavity and closing the abdominal wall tightly about it. Water was run into the peritoneal cavity by gravity. In order to establish excessive pressures, a hand pump was attached to the large gravity bottle, and air was pumped in above the fluid. The pressure in the abdomen was recorded by a Y connection to a mercury manometer. The arterial pressure was obtained from the carotid artery. Both arterial and intra-abdominal pressures were recorded on a revolving drum. No measurements of the normal intra-abdominal pressure were made. The intra-abdominal pressures used were higher than those observed in most patients with ascites. A constantly uniform intra-abdominal pressure could not be maintained, owing to the gradual stretching of the abdominal wall. The effect of sudden decompression of the abdomen by quick incision was noted. All experiments were performed under ether anesthesia.

#### COMMENT

Experimental ascites was established in twelve dogs, water pressures averaging from 40 to 50 cm of water being employed. In a few animals this pressure was exceeded at times, and again lower pressures were

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<sup>9</sup> Thorington, J. M., and Schmidt, C. F. A Study of Urinary Output and Blood Pressure Changes Resulting from Experimental Ascites, *Am J M Sc* **165** 880, 1923.



gradually returned to the normal level. In another dog in which the intra-abdominal pressure was increased to only 30 cm of water pressure (22 mm of mercury), only a slight and transient fall of arterial pressure accompanied the quick release of the increased intra-abdominal pressure.

The sudden decompression of the distended abdomen was also practiced in three dogs in which simple severed gut obstructions had been established in the duodenum two days previously. In these animals, the dyspnea caused by the same increase in intra-abdominal pressure was considerably more in evidence. In experiment II in the accompanying illustration is shown the fall in blood pressure in such an animal caused by the increase in intra-abdominal pressure. Following the sudden release of the ascites by incision, death occurred in two of the three animals. In the other animal, a marked reduction of arterial pressure was observed, but the blood pressure was gradually reestablished at the normal level as obtained following quick release of the increased pressure in the normal animal.

In the five other dogs for which tracings were made, an attempt was made to determine what factors would diminish or inhibit this fall in arterial pressure. In experiment III, the slight reduction accompanying gradual decompression of the distended abdomen is shown. Following a sudden release of the increased intra-abdominal pressure, the usual marked fall in arterial pressure was observed. When the intra-abdominal pressure was quickly reestablished after sudden decompression, the arterial pressure also quickly rose again. In two animals it was observed that a preliminary subcutaneous administration of solution of pituitary in great measure inhibited the marked fall in arterial pressure which would otherwise follow when the distended abdomen was incised (experiment IV). In two other dogs, results of the same nature but less marked than those following the use of solution of pituitary were observed when the blood volume was increased just before or after decompression of the abdomen by transfusing 400 cc of saline solution into the jugular vein. That the increased intra-abdominal pressure probably does not completely compress the inferior vena cava is shown in experiment V. Here the experimental ascites caused an increase in the arterial pressure. Following a gradual release of the increased intra-abdominal pressure, a marked fall was obtained when the circulating blood volume was reduced by clamping the inferior vena cava.

#### SUMMARY

When the markedly distended abdomen is incised, the same precaution of decompressing it slowly, as in paracentesis of the abdomen or chest, should be observed. In practice, circulatory collapse following incision of such an abdomen apparently does not occur with any degree



at 10 45 At 10 50 the blood pressure had fallen to 138 mm, and the dog was manifesting marked evidence of dyspnea At 11 00, a blood pressure of 80 mm was present, at 11 10, a blood pressure of 60 mm Blood pressure was sustained at this level to 11 20 When the ascites was released by a quick stab of the abdomen, the pressure suddenly fell to 50 mm of mercury, and in a few minutes the dog was dead

EXPERIMENT 3 (April 27, 1927) —Experimental ascites in normal dog to illustrate the effect from the gradual and sudden release of intra-abdominal pressure The tracing was started at 4 10 The blood pressure was 150 mm The pressure was sustained at this level, and at 4 25 a cannula was introduced into the abdomen At 4 30, a water pressure of 40 cm (30 mm of mercury) was started The arterial pressure maintained itself at the same level At 4 40, the pressure was slowly released by lowering the bottle of water used to obtain the pressure No effect on the blood pressure was noted A gradual reduction of pressure to 130 mm had obtained at 4 45 At this time, the ascites was again quickly reestablished, the arterial pressure quickly rose and maintained itself at 160 mm At 4 50, the ascites was quickly released by a stab wound of the abdomen, and the arterial pressure fell to 80 mm At 4 55, the blood pressure was 100 mm of mercury Ascites was again established, and the arterial pressure gradually rose to 130 mm at 5 00 At 5 05, the pressure was still the same The ascites again was quickly released, and the blood pressure fell to 80 mm and sustained itself at this level when the experiment was discontinued at 5 15

EXPERIMENT 4 (May 6, 1927) —Experimental ascites to note the effect of solution of pituitary on the quick release of intra-abdominal pressure At 10 00, the experiment was begun The arterial pressure was 220 mm of mercury At 10 10, there was a gradual reduction to 200 mm At 10 15, the pressure was 220 At 10 20, a cannula was introduced into the abdominal wall At 10 25, arterial pressure was the same Two ampules each containing 1 cc of surgical solution of pituitary were injected at this time Pressure sustained itself at the same level At 10 30, ascites was begun At 10 40, the ascites was quickly released by a stab wound in the abdomen A sudden fall of arterial pressure to 160 mm, with recovery in two minutes to 180 mm Pressure was sustained at this level until the experiment was discontinued at 10 50

EXPERIMENT 5 (May 17, 1927) —Experimental ascites The effect of a previous intravenous injection of saline solution was noted, also clamping of the inferior vena cava The experiment was started at 10 50 The blood pressure was 180 mm of mercury A cannula was inserted into the abdomen at 11 00 The blood pressure was 160 mm At 11 10, it was the same At 11 15, experimental ascites was started, water pressure of 60 cm (45 mm of mercury) was employed Following the increase of abdominal pressure, there was a gradual fall of arterial pressure in two minutes of 120 mm of mercury with a gradual rise in five minutes to 140 mm The pressure sustained itself at this level At 11 30, 400 cc of saline solution was introduced into the right jugular vein The blood pressure rose to 160 mm of mercury and sustained itself at this level for about five minutes, then gradually fell to 140 mm at 11 50 and sustained itself at this level for about ten minutes The abdomen had meanwhile been incised with just a transient fall in pressure. At 12 00, the inferior vena cava was clamped, with a sudden fall in blood pressure to 76 mm Pressure was sustained at this level At 12 05, 400 cc. of saline solution was again introduced into the jugular vein, this caused a gradual rise in arterial pressure to 120 mm at 12 15 The clamp on the inferior vena cava was removed The blood pressure rose to 140 mm and sustained itself at this level





flexion The author felt that this method is preferable to the so-called "shelf operation"

[ED COMMENT—The figure of 60 per cent for good functional results, reported by Willard, conforms more or less closely to the figures obtained in previous studies of the end-results of the same type The bilateral dislocations present the greatest difficulties and are the ones which yield the worst results Sufficient evidence to this effect has accumulated, and we believe that we must look to open reduction in properly selected cases for further improvement in the results The value of Eikenbary's procedure cannot be judged from the report of the result in a single case]

*Congenital Clubfoot*—Orthopedic surgeons have not generally agreed as to the best method of treating patients with congenital clubfoot, some have employed forcible correction, while others have used gentle and repeated manipulation By experiments on feet that were about to be amputated, Buerkle de la Camp<sup>3</sup> tried to show that forcible methods are harmful and may cause lasting injury Dissection of the amputated specimens showed that tearing of the capsule of the joint, avulsion of cartilage and bone and, likewise, compression of the cartilage and bone had taken place The author therefore concluded that the better method is the one aiming at repeated partial corrections with absence of force He did not consider open operation necessary in children

*Hereditary Hypermobility of Joints*—Key<sup>4</sup> reported the study of a "double-jointed" family, in which the abnormal hypermobility of the joints is present in all of the male members, and is absent in all of the females The condition appeared in the father and was not present in his parents, in any of his nine brothers or in his sister It was transmitted by the father to all of his four sons, but not to any of his daughters It thus acts as a "sex linked characteristic"

#### DISTURBANCES IN THE GROWTH OF BONE

*Coxa Valga and Osteochondritis*—Ettorre<sup>5</sup> discussed the theories regarding the causes of coxa valga, especially the one expressed in an article by Walter Mueller, who considered that the cause of coxa valga is an outward displacement of the epiphysis of the head on the neck From a study of roentgenograms in his own cases, Ettorre drew the

3 Buerkle de la Camp, H München med Wchnschr **74** 974 (June 10) 1927

4 Key, J Albert Diagnostic Problems in Hip in Early Life, J A M A **88** 1710 (May 28) 1927

5 Ettorre, E Policlinico **34** 58 (Feb 15) 1927



Recent studies seem to show that the substance present in ordinary sterols of both animal and plant origin, which is responsible for their activation by ultraviolet rays into antirachitic potency, is ergosterol or some kindred substance. Rosenheim and Webster<sup>8</sup> made tests of irradiated ergosterol which showed an astonishing degree of potency. A daily dose of 0.0001 mg. cured and prevented rickets in rats kept on a rachitogenic diet. Even this does not represent the maximal antirachitic potency of the new product. The authors stated that 5 mg. is equivalent to 1 liter of a good cod liver oil. At the same time a dose 10,000 times greater than what is now regarded as an effective dose did not produce any obvious ill effects on rats. The authors concluded that the naturally occurring parent substance of vitamin D is ergosterol or a sterol possessing the same absorption spectrum and physiologic activity.

Kramer and his associates<sup>9</sup> succeeded in preparing a cholesterol-free concentrate of cod liver oil which has the same antirachitic potency as cod liver oil. When injected subcutaneously in an ether solution the concentrate cured experimental rickets in rats. The same concentrate was inactive when injected subcutaneously with palmitin as the solvent.

Smith<sup>10</sup> made a study of the incidence of rickets in 597 children living under excellent hygienic surroundings in a small city in the western Rocky Mountain region, with the same latitude as New York City and an elevation of 4,310 feet. Of these children, 18.2 per cent were found to have rickets. The author felt that this low incidence is to be accounted for by the good hygienic conditions, the abundant sunshine and outdoor life and the greater values in ultraviolet radiations of the sunlight at this altitude.

*Osteomalacia*—Chabrol and his associates<sup>11</sup> reported the observations at necropsy in a well known case of osteomalacia, that of a man (Godezeme) who had provided the material for numerous reports by Berger from 1899 to 1905. After twenty-five years passed in a Bonnet's apparatus, the man died from pneumonia, in 1922. The case is of interest, first, because it occurred in a man, and Durham was able to find only 13 such cases out of 145 reported in the literature and, second, because the disease had undergone a spontaneous resolution, whereas usually it progresses rapidly in men, with death at the end of from four to five years, the extreme limits being one and eleven years. The osteo-

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8 Editorial, J. A. M. A. **88** 1969 (June 18) 1927

9 Kramer, B., Kramer, S. D., Schelling, D. H., and Shear, M. J. J. Biol. Chem. **71** 699 (Feb.) 1927

10 Smith, E. H. California and West. Med. **26** 341 (March) 1927

11 Chabrol, E. Presse med. **35** 275 (March 2) 1927

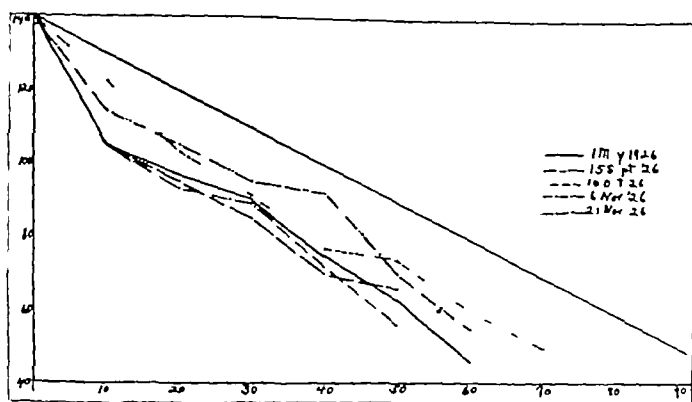


Chart 6—Neutralization of gastric acidity after administration of 0.5 per cent hydrochloric acid. Results obtained in a dog treated by intraperitoneal section of the vagi over a period of seven months following operation and compared with the average normal curve which is represented by the heavy straight line.

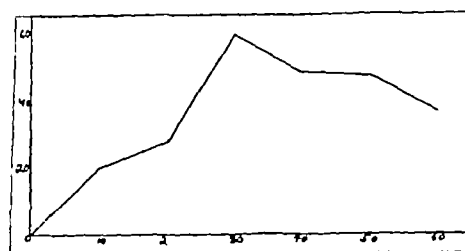


Chart 7—Secretion of hydrochloric acid after injection of histamine in a dog in which the intrinsic nerve supply of the stomach was sectioned by incision of the muscularis and submucosa.

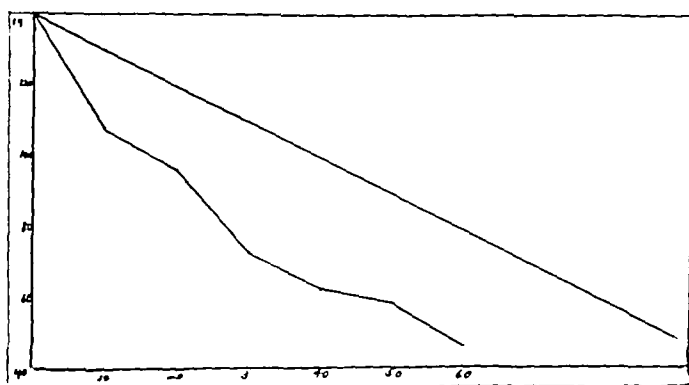


Chart 8—Neutralization of gastric acidity after administration of 0.5 per cent hydrochloric acid in a dog treated with circumcision of the gastric muscularis and submucosa and compared with the average normal curve which is represented by the heavy straight line.

resected specimens On careful examination, Koenig found them present in more than 50 per cent He was able to demonstrate them roentgenologically, however, in only twelve of ninety-eight cases From comparison of the roentgenograms with the specimens, he concluded that a cavity in the bone filled with tuberculous granulations can usually be shown, but that minute foci and infarcts cannot be seen

[ED COMMENT—This article serves only to emphasize what has been frequently pointed out before, namely, that absence of involvement of the bones cannot be claimed except after repeated and prolonged search of the specimen The more carefully the material is studied microscopically, the more constantly foci are found in the bone ]

*The Significance of Abscess in Pott's Disease*—Massart and Ducroquet<sup>14</sup> were convinced that abscess is a constant part of the lesion of vertebral tuberculosis and not merely a complication of it It is of the greatest possible diagnostic significance, and in cases in which the diagnosis is in doubt the roentgenologic examination should be repeated until one is certain of either the absence or the presence of abscess In the lumbar and cervical regions, the abscess is of the migrating type and can usually be palpated In the dorsal region, the abscess is confined by the vertebral ligaments and remains concealed except for roentgenologic demonstration

*Catheterization of Spinal Abscess*—In describing his technic for relieving the pressure of the abscess on the spinal cord in patients with Pott's disease with paraplegia, Calvé,<sup>15</sup> stated that a canaliculated sound, appropriately curved, is introduced into the anterior extradural space through the intervertebral foramen, effecting a kind of catheterization Pus appears in the sound immediately after puncture, aspiration usually being unnecessary He employed this procedure sixty-six times, and it has never led to any ill effects except in one instance in which it occasioned girdle pains He treated eighteen patients with grave paraplegia by this method, and ten of them remained under observation long enough for him to know the results In seven the paraplegia disappeared, although previous orthopedic treatment, which had been continued for months, had not been of any avail

[ED NOTE—One of the editors saw several of the patients who were treated by Calvé and has been impressed with the method which on demonstration seems safer and easier than would appear from the description ]

14 Massart, R, and Ducroquet, R Arch franco-belges de chir 29 181 (March) 1926

15 Calve, Jacques Arch franco-belges de chir 29 218 (March) 1926



when the line of demarcation between dead and living bone has become well defined, and when enough new bone has formed to insure the strength of the shaft Thornton described his operation procedure as a "sculpturing operation," in which the diseased area was thoroughly exposed with the aid of a tourniquet, all bone sinuses were eliminated, and all bone cavities made shallow Incisions should be made whenever possible so that muscle flaps will be made available to fill in the cavities The wound is packed with dry gauze, which is removed in five days, and thereafter daily dressings are made with gauze coated with petrolatum

#### ANTERIOR POLIOMYELITIS

*Experimental Poliomyelitis in Rabbits*—Jemma<sup>19</sup> made a careful experimental study of poliomyelitis in rabbits and drew the following conclusions 1 It is possible to reproduce anterior poliomyelitis experimentally in rabbits by injections of cerebrospinal fluid from sick children provided that young animals weighing not more than 700 or 800 Gm are chosen and that the cerebrospinal fluid used is from children who have been ill for from one to five days 2 Transmission is possible from rabbit to rabbit, an emulsion of infected nerve substance either direct or preserved in glycerine for several months being used

[ED COMMENT—We believe that heretofore it has usually been considered impossible to reproduce experimental poliomyelitis in any other animal than the ape ]

*Results of Treatment with Poliomyelitis Antistreptococcus Serum*—Rosenow and Nickel<sup>20</sup> summarized their results in the treatment of acute poliomyelitis with poliomyelitis antistreptococcus serum as follows

Altogether, the results in 1,113 patients with poliomyelitis who received serum and in 278 control untreated patients are illuminating The mortality rate was found to be much lower in the treated than in the control group, especially when the serum treatment was begun early, even if there were bulbar symptoms This was true in each of the four age groups (up to five years, from 6 to 10, 11 to 15, 16 years or more) in each of the five years from 1921 to 1925 as well as in each epidemic studied

The incidence of residual paralysis was also much lower in the treated than in the control group, especially in those patients who received serum before or soon after slight paralysis had developed The mortality rate and the incidence of residual paralysis in the control group were not abnormally high and correspond closely to those untreated patients whose cases are reported in the literature The incidence of the more severe initial symptoms, the average cell count, and the incidence of initial bulbar types of disease were somewhat higher in the treated than in the control group The age incidence was about the same in the two groups The good effect of the serum occurred inde-

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19 Jemma, G *Pediatrics* **34** 1363 (Dec 15) 1926

20 Rosenow, E C, and Nickel, A C Treatment of Acute Poliomyelitis with Poliomyelitis Antistreptococcus Serum, *Am J Dis Child* **33** 27 (Jan ) 1927





*Metabolism in Rheumatism*—Ellis<sup>22</sup> believed that all forms of rheumatism are fundamentally biochemical in origin and that the variety is largely determined by the constitutional characteristics of the person affected. He believed that these characteristics can be definitely recognized and classified by an examination of the urinary secretions. Life as biochemically considered is chiefly an acid function in an alkaline or neutral medium. The fires of life are producers of acid. The metabolic balance of an organism will depend on its capacity for producing acid, and the balance can be ascertained by a study of the acid excreted in the urine. This excretion is in two forms—free acid and acid combined with ammonia. An acid constitution is that in which the free acid is approximately the same as the combined acid. When the ratio is two to one in favor of the ammonia combined acid, one has the average normal or balanced constitution, and in the third group, which is relatively deficient in free acid, a proportion of three or more to one, one has the alkaline constitution. Ellis said that rheumatism is a metabolic condition and can be divided into four essential metabolic groups:

- 1 Arthritis deformans or progressive polyarthritis, the so-called septic variety. This is caused by general metabolic deficiency, presents the characteristics of a trophic neurosis, and results principally from a deficiency in phosphoric acid but is frequently activated by aseptic forms.
- 2 Osteo-arthritis, which results from a general metabolic excess without essential neurotic involvement. It is caused by accumulation of waste material through deficient elimination. It is principally activated by trauma or overwork of the part involved.
- 3 Climacteric arthritis due to want of glandular balance, which is described as endocrine arthritis. It is caused by functional changes similar to those produced by the menopause, and it is sometimes activated by a septic focus.
- 4 Gouty arthritis, which is due to uric acid and is produced by excess deposits of sodium urate and deficient elimination of uric acid resulting from derangement of the purin metabolism. The treatment of patients with metabolic deficiency has been directed to remedying the deficiency in assimilation and giving acid tonics and metabolic stimulants. This is largely a disease caused by deficiency in phosphoric acid. The type of rheumatism caused by metabolic excess requires the opposite type of treatment, as the deposits are the result of metabolic combustion in excess of the eliminating capacity. Fluids are demanded in this form, with the exception of partially fermented alcohol or sugary drinks.

*Dysenteric Arthritis*—According to Besson and Ehringer,<sup>23</sup> the agglutination reaction is of aid in the diagnosis of dysenteric arthritis. They reported a case in which the knee and elbow joints became inflamed.

22 Ellis, H. A. M. J. & Record **125** 437 (April 6) 1927.

23 Besson, A., and Ehringer, G. Paris med **2** 329 (Oct 30) 1926.



## DISTURBANCES OF THE NERVES

*Cortical Injections for Athetosis*—Although it is still a matter for discussion whether athetosis is due to disturbances of the cortical or subcortical centers, Nasaroff<sup>33</sup> reported that he has been able to obtain striking results in typical cases by the injection of alcohol in the cortex of the affected area, according to the method of Rasumowsky. He considered this method less dangerous than Horsley's operation. He described a case in which the involuntary motions of the hand ceased a few weeks after the injection, voluntary motions returned, and the hand again became useful. In another case, 0.5 cc of 80 per cent alcohol was injected into the region of the arm and hand centers. For the first few days after operation the hand was parietic, and soon afterward active motions were noted. Two months later, the patient was able to use the hand for definite tasks, and the athetoid movements had not reappeared.

## CIRCULATORY DISTURBANCES

*Trophic Disturbances in Buerger's Disease*—Boyer and Thibault<sup>34</sup> called attention to the possibility of Buerger's thrombo-angitis obliterans being due primarily to neurotrophic disturbance. Analysis of the case histories showed that pain was the first symptom, and they believed that this pointed to a neuritis. They also found evidences of trophic disturbances, and they believed that there are cerebrospinal symptoms antedating the appearance of the vascular lesions. As long as the origin of the condition is unknown, one should be on the lookout for evidences of disturbance of the nerves, and in cases coming to autopsy the examination should include systematic search for minute lesions in the cerebrospinal and sympathetic systems. Boyer and Thibault suggested a neurotrophic virus as the real etiologic factor.

*Innervation of Vessels*—Magnus<sup>35</sup> made a study of the innervation of blood vessels and used the capillary microscope and photographs to record the changing conditions. He was unable to find any physiologic, or even a theoretical basis, for the operation of periarterial sympathectomy. Local rises in temperature and hyperemia are noted after many operations and traumatic disturbances, and it is only in this way that he can account for the reputed benefits of the operation.

*Histologic Changes in the Vessel Walls After Sympathectomy*—Jegorov<sup>36</sup> performed experimental periarterial sympathectomy in twenty-six dogs and obtained specimens of the vessels operated on at different periods, in order to follow the changes consequent to the opera-

33 Nasaroff, N. N. *Zentralbl. f. Chir.* **54** 1478 (June 11) 1927.

34 Boyer, G., and Thibault, G. *Presse med.* **35** 100 (Jan. 22) 1927.

35 Magnus, G. *Arch. f. klin. Chir.* **143** 574, 1926.

36 Jegorov, B. *Russkaja klinika* **2** 46, 1924.



paring these with the failures, the author stated that there were nineteen deaths, two of them being due to suprarenal deficiency, and that in addition there were a number of postoperative accidents. Herzberg concluded that the operation has been based purely on hypothetical grounds, and that lacking anatomicopathologic and biochemical foundations, it has also failed to receive any justification from the clinical side.

[ED COMMENT—We believe that this sweeping denunciation of the operation of suprarenalectomy which is based on the author's personal experience and on careful investigation of the experience of others ought to settle the place of the operation in the treatment of circulatory disturbances.]

to be negative. Wagoner<sup>5</sup> (1926) recently also recorded subatmospheric measurements of intra-abdominal pressure on patients, animals and cadavers.

Emerson carried out experiments on rabbits, cats, dogs and calves. A slightly positive intra-abdominal pressure was usually observed. Debilitated states were found to show low pressures. With ether anesthesia and a complete loss of muscular tone, readings reaching zero or atmospheric pressure were observed. In quiet respiration the diaphragm was the chief factor in fluctuations of the intra-abdominal pressure. Consequent on the greatly increased muscle tension incident to asphyxia, a marked rise in intra-abdominal pressure was observed and sustained until terminal muscular relaxation occurred, when the pressure fell.

Helen Coombs<sup>6</sup> (1922) stressed the importance of the reflex tonicity of the abdominal musculature in determining intra-abdominal pressure. She referred to this factor as "postural activity." She found that when the abdomen of the cat is gradually distended with saline solution, a reflex lengthening of the abdominal muscles occurs, so that a considerable volume of fluid can be introduced without altering the intra-abdominal pressure. After about 500 cc. of fluid has been allowed to run in, a point is reached at which a sudden increase in intra-abdominal pressure occurs. She referred to this as the critical pressure. It is usually observed when enough fluid has run in to make the respiration markedly costal in character.

The effect of increased intra-abdominal pressure, as produced in experimental ascites on the blood pressure, has also been the subject of considerable study. Henriëus<sup>7</sup> (1890) observed that an increase of intra-abdominal pressure in cats or guinea-pigs of from 27 to 40 cm. of water was fatal due to the inhibition of respiration by interference with thoracic expansion. Hamburger<sup>8</sup> (1896) found that an increase of intra-abdominal pressure up to 25 cm. of water (18.5 mm. of Hg) caused a rise of from 10 to 15 mm. of Hg in the arterial pressure. Increase of the intra-abdominal pressure above 25 cm. of water caused a fall in arterial pressure. Hamburger also found that pressures of from 40 to 45 cm. of water would cause death of the animal about by heart failure.

Emerson also found that intra-abdominal pressures normal in the experimental animal caused a fall in arterial pressure.

5 Wagoner, G. W. Negative Intra Abdominal Pressure. *Am. J. M. Sc.* **171**: 697, 1926.

6 Coombs, Helen C. The Mechanical Aspects of Intra-abdominal Pressure. *Am. J. Physiol.* **61**: 150, 1922.

7 Henriëus, G. Ueber den Einfluss der intra-abdominalen Druck auf die Respiration. *Ztschr. f. Biol. Gewebelehre*, **8**: 117, 1890.

8 Hamburger, H. J. Ueber den Einfluss des intra-abdominalen Druckes auf die Allgemeine Arterielle Blutdruck. *Arch. f. Anat. u. Physiol.*, 1896.

## PAST PRESIDENTS

- 1918 SAMUEL J MELTZER, New York
- 1919 WILLY MEYER, New York
- 1920 WILLY MEYER, New York
- 1921 RUDOLPF MATAS, New Orleans, Pa
- 1922 SAMUEL ROBINSON, Santa Barbara Calif
- 1923 HOWARD LILIENTHAL, New York
- 1924 CARL A HEDBLUM, Chicago, -Ill
- 1925 NATHAN W GREEN, New York
- 1926 EDWARD E ARCHIBALD, Montreal, P Q
- 1927 FRANZ TOREK, New York

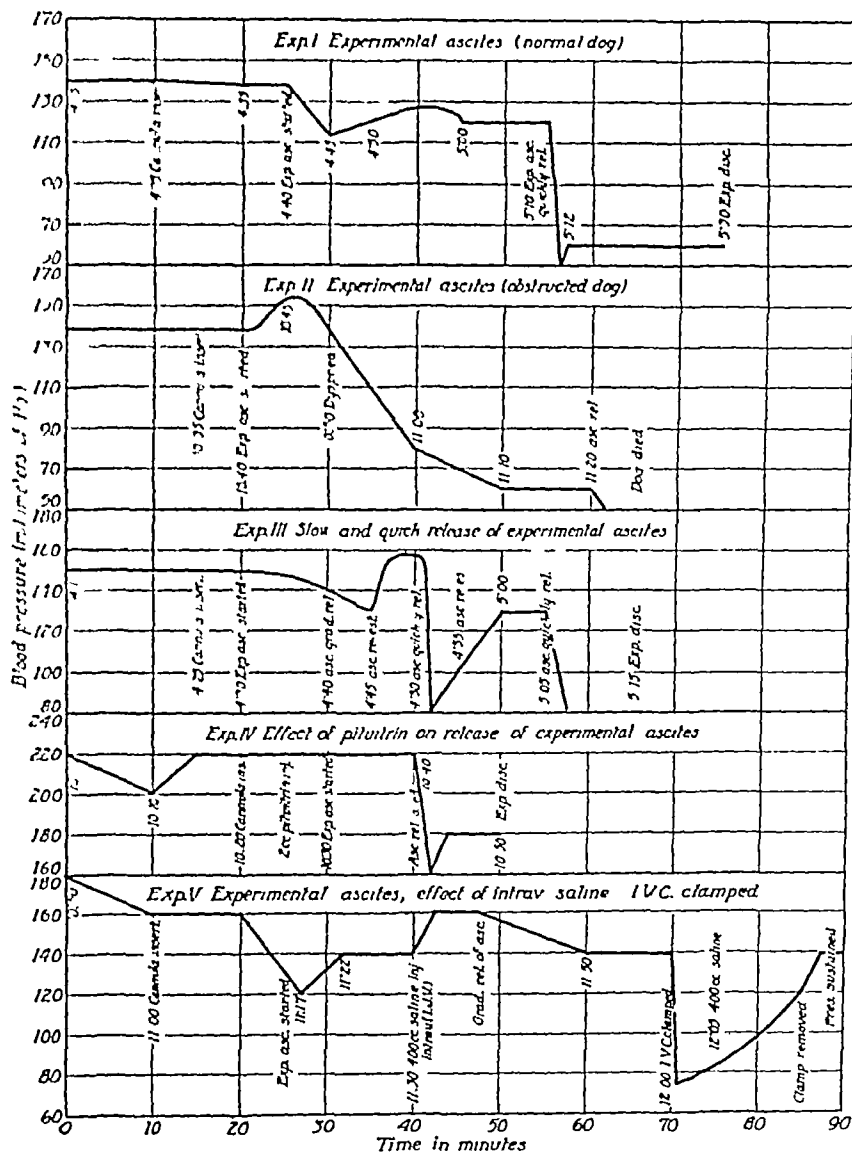
## PAST SECRETARIES

- 1918-1922 NATHAN W GREEN, New York
- 1922-1924 CHARLES GORDON HEYD, New York
- 1924-1928 ETHAN FLAGG BUTLER, Sayre, Pa

## MEETING DATES

- 1918 CHICAGO, June 10
- 1919 ATLANTIC CITY, N J , June 9
- 1920 NEW ORLEANS, May 1
- 1921 BOSTON, June 6
- 1922 WASHINGTON, D C , April 29
- 1923 CHICAGO, May 28
- 1924 ROCHESTER, Minn , June 5
- 1925 WASHINGTON, D C , May 4
- 1926 MONTREAL, P Q , September 30
- 1927 NEW YORK, May 9

occasionally employed. This increase in the intra-abdominal pressure was usually accompanied by a fairly well marked dyspnea. After the intra-abdominal pressure had been sustained at the new level for some time, the abdomen was suddenly decompressed in three normal dogs by quick incisions. In all the animals, a marked immediate fall in blood pressure occurred. However, a fatality was not brought about by this



Blood pressure tracings illustrating the effect of sudden release of an increased intra-abdominal pressure on the arterial pressure (I and II), and factors that modify this effect (III, IV, V)

sudden release of the intra-abdominal pressure in the normal dog. Following the sudden decompression of the abdomen in one animal (first tracing), a rise in the arterial pressure did not occur during the next twenty minutes of observation. In the other two animals, the pressure



has been made, this is replaced by the surgeon's fingers, if they are not too large. This extreme care in making the dissection must be continued till the pleura has been detached beyond the rib above and beyond the rib below the intercostal space, after which McBurney retractors may be inserted, care being taken that the pleura is not pinched by them. Before exerting any traction on the two ribs, one should make sure that the pleura is detached well beyond the anterior and posterior ends of the intercostal incision, as the pleura would be torn at those places if the ribs were drawn apart while it is still attached to them in front and behind. The continuation of the procedure of detaching the pleura becomes much easier now, when retraction is used and the fingers can be more easily introduced. When the pleura has been detached from the seventh and sixth ribs posteriorly, the seventh rib may be divided near the spine. This gives a great deal more space for the hand to continue the detachment higher up. When the fifth rib has been cleared, the sixth rib may be cut in the line of the posterior vertical incision, care being taken not to injure the pleura with the bone shears. The stripping of the pleura being continued farther upward, the fifth and fourth ribs may then be divided without danger of injuring the pleura. The rib spreader is introduced with caution so that its flanges do not catch the pleura anywhere. The separation of the pleura from the thoracic wall is continued till the entire costal pleura, from the apex to the diaphragm, has been detached, after which it is also separated from the spinal column, the aorta and the diaphragm. The detachment of the costal pleura is not difficult, except at the beginning, as has been mentioned. In one case, the patient detached his own pleura over a large area by a sudden, deep inspiration while he was going under the anesthetic, the skin and muscle incision having been made by paravertebral and regional block. It occurred so quickly, with a tearing sound, that my first thought was that he had made a rent into his pleura causing collapse of the lung, close examination, however, showed the pleura to be uninjured and in close contact with the partially collapsed lung. The task of detaching the pleura is more difficult where it covers the spinal column and the diaphragm. There the attachment is much firmer, and the separation requires some patience. The mediastinum is reached after the separation of the pleura has been continued mesially beyond the lateral wall of the aorta, and there the esophagus will soon be brought in evidence.

It is rather remarkable that so extensive a stripping of the pleura is practically bloodless. The lung collapses and sinks out of the way just as it does in the transpleural operation, except that the collapse is more gradual, keeping pace with the separation of the pleura. The exposure of the esophagus is as complete as in the transpleural operation, and the view is almost identical in gross appearance, for the parietal pleura, which has been separated from the wall of the chest, lies in close apposition with the lung and would be taken for its own visceral pleura unless closely examined.

The operation of resecting the esophagus is the same as in my method of transpleural resection,<sup>1</sup> the essential steps of which are the

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1 Torek, Franz. *Ann Surg*, April, 1915

of regularity. The potential for such an occurrence, however, exists and should be borne in mind. Two instances in which this phenomenon was observed are cited.

In most instances, when surgical intervention becomes necessary in the distended abdomen, the enlargement has been present for a long time. As has been pointed out, the intra-abdominal pressure in such instances is not actually increased greatly, owing to the stretching of the abdominal walls incident to the expansion of the abdomen. This situation is well illustrated in the pregnant abdomen. If such a readjustment did not already obtain, the sudden opening of the abdomen and uterus in cesarean section would be followed regularly by circulatory collapse.

Only in animals previously ill (in which duodenal obstructions had been present for two days) did a sudden release of the increased intra-abdominal pressure result fatally. In normal animals, a marked fall in arterial pressure occurred when the distended abdomen was quickly opened. A gradual return of the arterial pressure to the normal level usually followed. This occurrence could be obviated by a gradual release of the ascites, and it could be inhibited in large measure by the previous subcutaneous administration of solution of pituitary and in a lesser degree by the previous intravenous injection of saline solution. After this sudden circulatory adjustment had been brought about, increasing the intra-abdominal pressure again by approximating the edges of the incision and filling the abdomen with fluid, the intravenous infusion of saline solution or the administration of solution of pituitary hastened the return of the arterial pressure to the normal level.

#### PROTOCOL OF EXPERIMENTS <sup>10</sup>

EXPERIMENT 1 (April 18, 1927).—Experimental ascites in normal dog. The tracing was started at 4 15. The blood pressure was 140 mm. A cannula was inserted into the abdomen at 4 25. Blood pressure at 4 35 was 138 mm of mercury, at 4 40, it was the same. At this time the ascites was started. A water pressure of about 50 cm (37 mm of mercury) was employed. Following the increased intra-abdominal pressure there was a slight drop in the blood pressure to 114 mm at 4 45. At 4 50, the pressure had gradually risen to 120 mm and at 4 55 to 140 mm, with a gradual fall to 120 mm at 5 00. At 5 10, the pressure was still 120 mm. At this time, the ascites was quickly released by a stab wound of the abdomen and the arterial pressure suddenly fell to 50 mm. At 5 12, it had risen to 60 mm. It sustained itself at this level until the experiment was discontinued at 5 30.

EXPERIMENT 2 (April 20, 1927).—Experimental ascites in dog, with duodenal obstruction of two days' standing. The tracing was started at 10 20. The blood pressure was 138 mm. A cannula was inserted into the abdomen at 10 35. The blood pressure was the same. At 10 40, experimental ascites was begun, a water pressure of about 45 cm of water (33 mm of mercury) being used. Following this there was a gradual rise of arterial pressure to 160 mm of mercury.

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<sup>10</sup> The details of the remaining experiments are omitted.

branches of the aorta had to be divided at the arch. The tumor was adherent to the right pleura, from which it could not be separated, therefore the liberation of the tumor necessitated opening the right pleura. The esophagus was divided below the tumor, the lower stump was invaginated and the upper one brought out at the neck, where it



Fig 2—Roentgenographic appearance of chest the second day after Torek's extrapleural esophagectomy had been performed, attack from left side. The division of four ribs can be made out, though the lines are rather faint, owing to the perfect alignment of the cut ends. The chest is seen to be normally transparent on the side of the operation, whereas the right pleura, which was opened at operation, shows a haze.

was sutured. A cigaret drain was placed through the length of the mediastinum and was led out at the ninth space. The chest was then closed.

# THIRTY-FOURTH REPORT OF PROGRESS IN ORTHOPEDIC SURGERY \*

PHILIP D WILSON, MD  
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## CONGENITAL DEFORMITIES

*Congenital Dislocation of the Hip*—Willard<sup>1</sup> reviewed the results of reduction by the Davis method in twenty cases of congenital dislocation of the hip five years after operation. Six of the patients showed bilateral dislocations. Reports were made on twenty-six hips. The results were: Ten per cent failure, both bilateral dislocations, 30 per cent, reduced but unstable, 60 per cent of good functional results in all single dislocations. In studying the 30 per cent of the cases in which the dislocations were reduced but unstable, Willard felt that much of the change that takes place in the head and acetabulum after reduction is due to injury at the time of reduction. From this he advocated reduction (closed) before weight-bearing begins, if possible. Reduction should be accomplished by the gentlest sort of manipulations. The type of manipulation is of less importance than the amount of skill with which it is used. Open operation should be resorted to if manipulation fails.

Eikenbary<sup>2</sup> reported a congenital bilateral dislocation of the hip which was reduced by open operation when the child was 11, the patient was seen again at the age of 23. The operation consisted of enlargement of the acetabulum by means of a chisel and a heavy curet. The result thirteen years later was satisfactory, with 90 degrees motion in

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\* This Report of Progress is based on a review of 166 articles selected from 419 titles dealing with orthopedic surgery appearing in medical literature between March 12, 1927, and July 2, 1927. Only those papers that seem to represent progress have been selected for note and comment.

1 Willard, Deforest P. J Bone & Joint Surg 9 270 (April) 1927

2 Eikenbary, C F. Northwest Med 26 161 (March) 1927

# EXPERIMENTAL ABSCESS OF THE LUNG IN THE DOG \*

S J CROWE, M D  
AND  
JOHN E SCARFF, M D  
BALTIMORE

The American Association for Thoracic Surgery has done much to stimulate an interest in the etiology and methods of prevention of post-operative abscess of the lung. Tonsillectomy and other operations in the upper air passages that are carried out under general anesthesia are responsible for the largest number of the reported cases, but abscess of the lung does occur as a complication of tonsillectomy and extraction of teeth under local anesthesia and occasionally after appendectomy. It is true that a real abscess in the lung with cavity formation commonly follows an operation for a septic condition, but in studying the etiology of this type of abscess it might be well to consider the relation between post-operative bronchopneumonia (a complication in about 5 per cent of clean surgical operations, such as hernia) and infections of the lung that proceed to cavity formation. Are all abscesses of the lung due to infected emboli from the vessels surrounding the operative field, or is the aspiration of mouth secretions, bits of infected tissue and the plugs of detritus from the crypts of tonsils the common method of post-operative lung infection? Are the clinical and pathologic differences between bronchopneumonia, massive collapse of the lung and lung abscess determined by different routes of infection or by the type of the infecting organism and the resistance of the patient? These are questions that we are not prepared to answer, but they deserve consideration in the study of postoperative complications in the lung. The removal of tonsils under general anesthesia is the most talked-of cause of abscesses of the lung. Cutler and his associates, Holman and others ascribe these abscesses to the liberation of infected emboli, but our experience during the past twelve years at the Johns Hopkins Hospital, where 3,500 patients have had their tonsils removed under ether anesthesia without the occurrence of a single postoperative abscess of the lung, leads us to believe that aspiration is the cause of this complication. In each of these 3,500 patients the following safeguards against aspiration have been employed: 1 Hypodermic administration of morphine sulphate and atropine is employed about thirty minutes before the operation. 2 The anesthetic is administered by a trained anesthetist. 3 During the operation, the head of the patient is at least 15 inches lower than

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\* From the Department of Surgery, Johns Hopkins University

following conclusions 1 Coxa valga may occur without a displacement of the head, but through an insufficiency of the roof of the acetabulum, as in many spastic patients and in those with coxa valga luxans 2 Displacement of the head does not necessarily produce coxa valga 3 The displacement of the head can occur only when a pathologic process involving the epiphyseal line coexists, and in such a case, if a deficiency of the acetabulum is also present, coxa valva may develop Ettorre concluded that various factors may play a part in the production of coxa valga

*Osteochondritis of the Vertebral Body*—Buchman<sup>6</sup> described five cases in children who had disturbance of the spine which he believed belong to the class of cases already described, he attempted to draw a line between these cases and the cases of so-called vertebral epiphysitis He considered the first a disease of one of the primary centers of ossification and the second a disease of one of the secondary centers The age of the patient thus determines the type of lesion Buchman gave as his view of the cause of these conditions the fact that they are due to an increase in static demand, going hand in hand with a decrease in static capacity He discussed slipping epiphyses in the same relation but finally admitted that one seldom sees these conditions in infantile paralysis and infantile rickets, in which the “capacity” of the bone is obviously decreased

[ED COMMENT—We do not see that Buchman’s theory adds to the discovery of the causation of the condition The essence of Wolff’s law is that “static capacity” increases in proportion to “static demand” When the reverse is true, there is gross evidence of a pathologic disturbance, and the cause must be sought ]

#### NUTRITIONAL DISEASES OF THE BONE

*Rickets*—Investigations by Grayzel and Miller<sup>7</sup> tended to confirm the view that difficulty in intestinal absorption of calcium and phosphorus may be responsible for the abnormalities in metabolism of these elements which are found in rickets Their studies showed that with a normal diet the reaction remained acid with considerable constancy at different levels of the gastro-intestinal tract High variations in fat, protein, or carbohydrate did not cause notable changes The rickets-producing diet did, however, cause a definite rise in the  $p_H$  of the intestinal contents, even to the point of alkalinity Ultraviolet radiation or the administration of cod liver oil to dogs on the same diet caused an acidification of the contents to within the normal range

6 Buchman, Joseph J Bone & Joint Surg 9 55 (Jan ) 1927

7 Editorial, J A M A 88 1715 (May 28) 1927

some of the pus from the chronic suppuration in the frontal sinus flowed into the trachea, probably during sleep, and produced the isolated abscess in the lower lobe on one side. This supposition is supported by the demonstration with dark-field illumination of spirochetes in the frontal sinus after six weeks and in the lesion of the lung. Many other organisms could be seen in the smear from the abscess of the lung, but it is worthy of note that the Vincent bacillus was not found.

We have mentioned before that we succeeded in producing a chronic abscess of the lung only after two years of effort. In the fifty experiments made during these two years, we introduced, through the bronchoscope, pieces of cotton soaked with virulent cultures of pneumococcus, staphylococcus, several varieties of streptococcus, the colon bacillus and various types of fungi. Our results with these organisms were either negative or resulted in a diffuse infection of the lung, and are in accord with those of Cutler, Holman and others. It is striking, however, that the same procedure will result in a localized, chronic suppuration of the lung when the scrapings from pyorrhea cavities are used as the infecting agent. We realize fully that it cannot be inferred from these experiments on animals that the aspiration of spirochetes from the mouth is the cause of postoperative abscess of the lung in man, but this experimental observation is suggestive and shows the specificity of organisms. David T. Smith<sup>1</sup> of Ray Brook, N. Y., has been able to produce pulmonary abscesses in mice, guinea-pigs and rabbits by intra-tracheal injection of material from pyorrhea cavities. This same group of organisms is normally present in the material expressed from crypts in the tonsils. It has been known for many years that the foul odor of the sputum from a chronic abscess of the lung is due to spirochetes and that the intravenous administration of one of the arsenic compounds is of value in such cases. The spirochetes in the mouth have been regarded as secondary invaders, but it is possible that they may play an important rôle in the etiology of abscess of the lung which follows operations on the tonsils and teeth.

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<sup>1</sup> Smith, David T. Experimental Aspiratory Abscess, Arch Surg **14** 231 (Jan) 1927

malacia started when the patient was 20, under the form of genu valgum, for which Berger performed an osteotomy. The decalcification progressed rapidly during the first two years and then stopped for a while. In 1905, the patient's health was better, the pains had disappeared, and it was possible to perform motions with the right hand. The roentgenograms showed beginning recalcification. The remission lasted until the time of death, and this is the only reported case in which this has ever occurred. Between 1896 and 1905, the examinations of the urine showed tremendous elimination of calcium, often from 9 to 10 Gm. Autopsy showed that all the bones were twisted and deformed. Concretions that had been discovered sixteen years earlier by Berger during the active stage of the disease were found in the left renal pelvis. No change was discovered in any of the glands of internal secretion except the suprarenals, both of which were enlarged, the left one weighing 30 Gm.

#### TUBERCULOSIS

*Tuberculosis of the Knee and Hip*—Hibbs<sup>12</sup> studied the end-results in a group of cases of tuberculosis of the knee and hip in which the patients were treated by conservative measures. The diagnosis was incorrect in 30 per cent of the patients with tuberculosis of the knee, of the 67 remaining patients, 7 died from other forms of tuberculosis, and in 43 the disease became quiescent. In 16 of the latter, the disease again became active at a later period. Two hundred and eight patients had tuberculosis of the hip. The error in diagnosis was 22 per cent. Of those who probably had tuberculosis, 24 per cent died, of the 114 remaining, 17 still had active tuberculosis. In two, the disease was quiescent with free motion, and in four it was quiescent with marked limitation of motion. Fifteen patients had relapses after periods of quiescence varying from one to nine years. In the cases in which operation was performed, the results were better. Sixteen of the knees mentioned were fused, and all of these patients remained free from symptoms. The hip had been fused in more than 80 cases, and the results thus far obtained give promise of a high percentage of cures. Hibbs emphasized the point that diagnosis must be made by tests performed in the laboratory, and that many statistical studies are inaccurate because of errors in diagnosis.

*Occurrence of Foci in the Bones in Tuberculous Joints*—Koenig<sup>13</sup> pointed out the impossibility of determining the presence of foci in the bone in tuberculous joints by means of roentgenograms. Riedel reported finding foci present in the bones in more than 70 per cent of

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12 Hibbs, Russell A. Southern M J 20 278 (April) 1927

13 Koenig, Fritz. Zentralbl f Chir 54 1030 (April 23) 1927



## PREVIOUS INVESTIGATIONS

Clinical studies of the etiology of the various types of abscesses of the lung have indicated the probability that most of them are aspiratory in origin. Experimental results in animals, however, have not supported this.

The clinical studies of Richardson,<sup>1</sup> Scudder,<sup>2</sup> Whittemore,<sup>3</sup> Moore,<sup>4</sup> Singer and Graham,<sup>5</sup> Cutler and Schlueter,<sup>6</sup> Hedblom,<sup>7</sup> and numerous other investigators have revealed the fact that a considerable percentage of all nontuberculous abscesses of the lung follow operative procedures about the upper respiratory tract. There is, at least in this group of cases, ample opportunity for the aspiration of infectious material, and this opportunity is soon followed by the development of the abscess. Cutler found that 29 per cent of 1,908 cases of abscess of the lung followed operations, half of which were tonsillectomies.

The larger group of abscesses of the lung which do not follow operative procedures, about 65 per cent of all cases, has not received the close study that the postoperative group has had. The group of cases to be reported in this paper shows that most of this group of abscesses of the lung apparently follow infections of the respiratory tract.

The experimental production of abscess of the lung has been difficult. Kline<sup>8</sup> and Smith<sup>9</sup> have succeeded in producing acute aspiratory abscess by the insufflation of the bacteria obtained from the teeth. Cutler and his co-workers, Homan,<sup>10</sup> Schlueter<sup>6</sup> and Weidlein<sup>11</sup> have

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1 Richardson, C. W. Tonsillectomy with Consideration of Its Complications, *Wash. M. Ann.* **12** 2, 1912.

2 Scudder, C. L. A Report of the Cases of Lung Abscesses at the Massachusetts General Hospital Clinic, Boston *M. & S. J.* **171** 523, 1914.

3 Whittemore, W. The Etiology and Treatment of Non-Tuberculous Pulmonary Abscess, *Surg. Gynec. Obst.* **38** 461, 1924.

4 Moore, W. F. Pulmonary Abscess—An Analysis of 202 Cases following Operative Work about the Upper Respiratory Passages, *J. A. M. A.* **78** 1279 (April 29) 1922.

5 Singer, J. J., and Graham, E. A. A Study of Thirty-Four Cases of Abscess of the Lung, *J. A. M. A.* **83** 193 (July 21) 1923.

6 Cutler, E. C., and Schlueter, S. A. The Experimental Production of Abscess of the Lung, *Ann. Surg.* **84** 256, 1926.

7 Hedblom, C. A. The Surgical Treatment of Acute Pulmonary Abscess and Chronic Pulmonary Suppuration, *J. A. M. A.* **83** 1577 (Nov. 15) 1924.

8 Kline, B. S. Experimental Gangrene, *J. Infect. Dis.* **32** 481, 1923.

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## OSTEOMYELITIS

*Acute Hematogenous Osteomyelitis*—Robertson<sup>16</sup> produced experimental osteomyelitis in animals and reviewed the literature. He believed that the experimental work proves beyond any doubt that 1. Organisms introduced into the blood stream are deposited, among other places, in the long bones. 2. In bone, active phagocytosis is present, except in the metaphyses. 3. Organisms produce inflammatory centers in metaphyses independent of trauma. 4. It is impossible to produce a general infection of the medulla by a simple inoculation of organisms into the blood stream. 5. Trauma may determine a local infection. 6. Growing bones develop abscesses of the osteomyelitic type within them, adult bones do this rarely.

Robertson tried to correlate these observations with the clinical picture of osteomyelitis. His conclusions were as follows: 1. Staphylococcal infections come from lesions of the skin by contamination of the blood. 2. The primary lesion of the bone in man is determined by trauma. 3. Continued septicemia favors the formation of supplementary lesions of the bone. 4. The lesion of the bone is in the metaphysis of the growing child. 5. The chief symptom is pain, the chief sign tenderness over the involved metaphysis. 6. Treatment consists of early operation into the metaphysis for the purpose of drainage.

Wilenski<sup>17</sup> described the mechanism of acute osteomyelitis as, first, a bacteremia or general infection of the blood, second, the development of a fixation point in the vascular network of a bone (thrombo-embolic phenomenon), third, the development of a pathologic process characterized by thrombo-arteritis or thrombophlebitis, and fourth, the resulting necrosis of bone cells and tissue. He believed that the severity of the general infection may be determined by plating the blood cultures and counting the colonies. If bacteremia is not present, the prognosis is good. If many colonies are found, the infection may be of the acute fulminating type and there are practically no chances of help by operation. Between these two extremes is a large group of cases in which demonstrable bacteremia and one or more foci of osteomyelitis are present. If operation is performed early in these cases, the prognosis is good. If the bacteremia is severe, the operation must consist in radical removal of the thrombophlebitic focus.

*Treatment of Chronic Osteomyelitis*—According to Thornton<sup>18</sup> there are operable and inoperable stages of chronic osteomyelitis. Following the acute stage, all patients go through an inoperable phase. The operable stage is reached when new bone shadows have become dense

16 Robertson, D. E. *J. Bone & Joint Surg.* 9: 8 (Jan.) 1927.

17 Wilenski, A. O. *Ann. Surg.* 85: 428 (March) 1927.

18 Thornton, Lawson. *J. Bone & Joint Surg.* 9: 294 (April) 1927.

French, was moistened with sterile water and gently introduced deep into the respiratory tract. A small, dry, sterile basin was partly immersed in a larger basin of water at 40 C (104 F). The two basins were placed on the floor at the head of the anesthetized animal. A sterile 5 cc syringe was also immersed in water at 40 C. The patient was instructed to lean forward over a chair and to expectorate pus, which was coughed up into the small, warm basin. This pus was immediately aspirated into the warmed syringe, and 3 cc was injected into the bronchus through the previously placed catheter. Not more than thirty seconds elapsed between expectoration and instillation of the pus. The animal was placed in a comfortably heated room.

Feb 20 The dog was very lively, it ate and played.

Feb 21 The condition did not change.

Feb 23 The dog was active and leaped to greet us. There was no cough or rales, a roentgenogram did not show a shadow.

Feb 25 Maltese was not apparent. A roentgenogram did not show a shadow.

Feb 27 The dog was not so active in the morning. His temperature was 101 F. A roentgenogram did not show a shadow. There were no rales or dyspnea.

Feb 29 The dog was less active than at any previous time, but auscultation or percussion of the chest did not reveal any sign of abscess.

March 5 There were no physical signs of abscess. The dog looked haggard and was losing weight. He did not cough.

March 8 The dog did not cough and continued to lose weight.

March 11 The animal was markedly emaciated. He did not cough.

March 13 The dog was very emaciated and inactive. He did not cough. A roentgenogram showed mottling in the right side of the chest, but no abscess cavity.

March 14 The dog was found dead in the cage.

*Autopsy*—The pleural cavities did not contain fluid or pus. The right middle lobe was firm, but crepitant. Several small yellow areas presented themselves along its costal surface. The trachea was clamped, and the lungs were removed en masse. A longitudinal incision was made into the trachea, and it was found to contain about 3 cc of moderately viscid, yellow pus. The bronchus to the right middle lobe was filled with air containing pus.

The lungs were inflated through a cannula, and at the same time a roentgenogram was taken. Abscess cavities were not visible, but a dense portion of the lung could be made out. The gross and microscopic examination of the middle lobe was far more conclusive of the presence of multiple abscesses than the roentgenographic examination. The cut surface of the right middle lobe is shown in figure 2.

*Microscopic Examination*—Many areas were filled with polymorphonuclear leukocytes and fewer round cells. The alveolar epithelium was absent. These areas of necrosis and pus contained small bubbles of air and non-necrotic alveolar epithelium was found between them. Atelectasis was not marked in these areas. In many places, the remains of a bronchiole could be seen near the center of the abscess. Figure 1 shows one such bronchiole in which the epithelial lining has been eroded and only the fibrous tissue of the wall is intact. Epithelial casts can be seen clinging to the fibrous tissue ring. The infectious process penetrates the wall of the bronchiole at one place. Bacteria can be seen throughout the wall of the bronchiole and surrounding tissue, but bacteria were not found in the walls of the blood vessels or inside the vessels themselves. Spirochetes were not found.

pendently of spinal drainage. The results in the patients treated by others are in agreement with our results in this and in previous studies as regards mortality rate, incidence of residual paralysis, and bedside impressions concerning early good effects of the serum. The number and variety of the patients treated are sufficient, and control observations are adequate to justify the conclusion that this poliomyelitis antistreptococcus serum is of value in the treatment of acute anterior poliomyelitis. The serum used possessed the power of neutralizing the toxic material contained in cultures of streptococcus as measured by intracutaneous injection, it diminished the infective power *in vitro* of the streptococcus as measured by intracerebral injection, and it cured rabbits inoculated intravenously with the streptococcus, properties not possessed by horse serum. Some of the batches of serum neutralized the virus *in vitro*, and protected monkeys against poliomyelitis in the forced experiment by intracerebral inoculation of virus. Rabbits have been immunized against intracerebral inoculation of the streptococcus by the methods used in the preparation of the serum in horses, hence the curative action noted clinically would seem attributable to the specific antibodies contained in the serum and not to nonspecific or foreign protein effects.

[ED COMMENT—Rosenow failed to convince many competent bacteriologists that the streptococcus which he has isolated from patients with poliomyelitis bears any causal relation to that disease. Hence we hesitate to accept the conclusion that antistreptococcus serum is of specific benefit in the disease. While the results reported are suggestive, whether or not they are conclusive will have to be left to the judgment of more competent authorities. When patients are reported as having been treated with serum, it will be important to specify whether convalescent serum or Rosenow's serum has been used.]

#### ARTHRITIS

*Specific Causative Factors*—Hadjopoulos and Burbank<sup>21</sup> employed immune serum in order to determine by the reactions the types of infective organisms in cases of chronic multiple arthritis, they checked these by cultures from various foci of infection which had been discovered. They believed the streptococcus to be the main causative factor in both of these sources. By neutralization of the alexin in freshly drawn blood of arthritic patients, they were able to grow pure cultures of various organisms, streptococci, diphtheroids and *Staphylococcus aureus*. Taking the streptococci thus isolated, they were able to produce arthritic symptoms in animals by inoculating the blood with those organisms.

[ED COMMENT—Careful bacteriologic investigations have been made of chronic arthritis, usually with inconclusive results. The observations reported require confirmation.]

<sup>21</sup> Hadjopoulos, L. G., and Burbank, Reginald. J. Bone & Joint Surg. 9: 278 (April) 1927.

in the lung of a human being. The lesions were produced in healthy dogs in which opportunity for pulmonary embolism had not been established. Regarded both from the experimental and from the clinical point of view as well as microscopically, the abscesses were abscesses of the lung produced by aspiration.

An analysis of the twenty-one experiments in series II revealed the following significant facts. The animals in fifteen experiments failed to develop abscess of the lungs, and only three animals in the total twenty-one experiments developed abscesses. Each animal had received fresh, warm pus from patients with chronic abscess of the lung. Some of the animals which did not develop abscesses had received



Fig 2—Cut surface of lung containing abscesses. *A* indicates the abscesses which are remote from the main bronchus, *B*, the bronchus. The infectious material seems to have been trapped in the smaller bronchioles.

exactly the same amounts of the same pus and at almost the same minute as other animals that did develop abscess. Why did some of these animals develop abscess of the lung while others did not? Why does one patient develop a postoperative abscess of the lung while a second patient on whom a similar operative procedure has been carried out does not?

An examination of the lungs of those animals in which multiple abscesses had been produced by aspiration seemed to indicate an answer. Most of the abscesses were situated in those portions of the lung farthest removed from the main bronchus (fig 2). The infectious material must have been *trapped* in the smaller bronchioles and alveoli.

following the disappearance of intestinal symptoms. The aspirated fluid from the knee contained a large number of polymorphonuclear cells, but neither on microscopic study nor on cultures could any bacilli be found. Agglutination tests of the fluid proved positive for Shiga and Flexner bacilli and negative for Hess and colon bacilli. The results were the same in another patient with arthritis who had had diarrhea two weeks before. Besson and Ehringer concluded that the agglutination test is of value in differentiating this type of arthritis.

*The Protozoan Theory of Arthritis*—Barrows and Armstrong<sup>24</sup> discussed in detail the protozoan etiology of chronic deforming arthritis. In a series of 209 cases, 171 patients received medical treatment alone in which antiparasitic therapy played the chief rôle. From the clinical standpoint the results were considered satisfactory benefit being claimed in 93 per cent of the cases.

[ED. NOTE—Conclusive proof of the etiologic relationship of protozoa to arthritis has not yet been presented.]

*Blood Calcium and Phosphorus in Arthritis*—Nachlas<sup>25</sup> studied the level of calcium and phosphorus in the blood in arthritis. The reports in the literature on this subject show lack of agreement some observers claiming an increase and others no change. Nachlas' studies are in accord with the latter group. He was unable to demonstrate any change in blood calcium or blood phosphorus in either type of arthritis.

#### PAIN IN THE BACK

*Injuries of the Back in Industrial Employees*—Herndon<sup>26</sup> made a study of 941 consecutive cases of injury of the back among industrial employees, and his report gave an idea of the relative frequency of the various types of injury. Fifty-three per cent of the injuries were classified as sprains and of these two-thirds were in the lumbosacral region. Forty-one of the patients, or 4 per cent, had fractures of the vertebral processes, the transverse processes being injured in thirty cases. There were thirty cases of fracture of the vertebral body. Only one third of these showed involvement of the cord. Arthritis neurosis, malingering and other diseases accounted for the remaining cases. In conclusion Herndon stated that "the most frequent causes of unsatisfactory progress are failure to report the injury early to make a complete examination and diagnosis at once to prescribe efficient treatment, and to follow up this treatment."

<sup>24</sup> Barrow, J. V., and Armstrong, E. L. *California & West Med* 26: 322 (March) 1927.

<sup>25</sup> Nachlas, I. W. *J. Bone & Joint Surg* 9: 37 (Jan.) 1927.

<sup>26</sup> Herndon, Richard F. *J. Bone & Joint Surg* 9: 234 (April) 1927.

The lobe appeared solid, and beneath the pleura were many dark, yellow, indurated areas. The cut surface of this lobe showed many small abscesses, the bronchioles were filled with chocolate colored, foul pus. There were no large abscess cavities.

The right middle lobe was adherent to the surrounding lobes. Its tip projected stiffly and maintained its position beside the heart, while the right lower and upper lobes were collapsed. The right middle lobe was studded with yellow, indurated areas, with air-containing, crepitant lung tissue between them. Between the right lower lobe and the vertebral ridge, an intrapleural abscess was opened which contained about 10 cc of putrid, foul-smelling, chocolate-colored, granular pus. This was like the original pus from the patient both in color and in odor. Smears and cultures showed a fusiform bacilli and spirochete flora identical with that in the original pus. The trachea was clamped off and the lungs removed en masse.

The trachea and bronchi were lined with chocolate-colored, foul-smelling pus in which many small, cheesy, yellow masses were found. The bronchi to the right middle lobe and to the mediastinal lobe were filled with foamy pus. Incision along the bronchus to the middle lobe revealed the silk ligature hanging free in its lumen and attached by only a small section of its wall. The lumen of this bronchus was now patent—the ligature which was placed around it twenty-six days previously had cut through its wall. The smaller bronchioles which empty into this bronchus to the right middle lobe exuded pus when slight pressure was made on the external surface of the lobe. There were multiple small abscesses, varying from less than 1 mm to 8 mm in diameter, throughout the entire lobe. There were no large air-containing abscess cavities. The abdomen did not contain pus.

*Microscopic Examination*—Bacteriologic. Smears from the bronchioles of the right middle lobe, from the mediastinal lobe, and from the trachea showed an identical bacterial flora. Cocci, fusiform bacilli and spirochetes were present in a profusion. The yellow granules swarmed with spirochetes—dozens were present in each oil immersion field. Cultures showed *Diplococcus melanogeniticum*.

*Pathologic*. The sections showed that in certain areas the alveoli were replaced by a solid mass of polymorphonuclear and round cells. Here the alveolar epithelium was entirely absent. In places, many of the alveoli were still outlined by capillaries containing intact red blood cells. The blood vessels were still patent in the sea of pus (fig 3). There were no emboli, even in the smaller capillaries. The bronchioles were filled with pus, and in many places the epithelial lining of the bronchioles was missing.

This experiment was repeated, warm minced tonsil being used instead of pus from the abscess. The crypts of the tonsil contained myriads of spirochetes. Fusiform bacilli and cocci were also present. The animal pursued the same postoperative course as the first animal, except that the thoracotomy wound did not break open and he did not cough. This animal showed malaise at the end of the ninth day after injection.

The second animal was killed on the twenty-first day. Multiple abscesses were found in the right middle lobe. The bronchus to this lobe had also reestablished the patency of its lumen, the silk ligature having cut through its walls. At autopsy, yellow granules containing myriads of spirochetes were found in the pus in the bronchus to the right middle

tion He summarized these changes as follows The vitality of the artery was much altered, the contractile elements were replaced by connective tissue The changed nutritive conditions led to the deposition of fat within the endothelial cells The muscles lost their characteristic staining reaction and showed distinct signs of necrobiosis Fifty days after the operation, the lumen of the collateral vessels was wider than on the normal side and the media was hypertrophied From a consideration of these changes the author pointed out the inadvisability of performing the operation in cases in which the vessels have been altered in such a way as to lose their elasticity

*Oscillometry in Circulatory Disturbances of the Extremities.*—Samuels<sup>37</sup> described the oscillometer of Pachon and discussed its use in studying various arterial disturbances in the extremities He concluded that it is a valuable adjunct and should be used as a part of the general physical examination in any case in which circulatory disturbance is suspected It is of value in the diagnosis of early occlusive disease of the peripheral arteries and in the differentiation of neurogenic from organic arterial disease By its aid, the progress of arterial disease in the extremities can be studied quantitatively The instrument exhibits certain physical limitations, such as its inability to select any one vessel for study and its insensitivity to that state of the circulation represented as lying between the zero point of the instrument and the total cessation of arterial outflow

*Results of Suprarenalectomy in Spontaneous Gangrene of the Extremities*—Seneque<sup>38</sup> summarized the report of an investigation by Herzberg, a Russian surgeon of the results of suprarenalectomy Herzberg was able to collect reports of 112 cases, including 58 cases of Oppel (who, in 1921 published the theoretical basis for the operation), 6 cases of Leriche, 8 personal cases, and the rest representing the cases of various Russian surgeons Of the 112 cases a cure (meaning complete disappearance of pain with cicatrization of the ulcers) was obtained in 14 cases However these so-called cures have not existed for a sufficient period of time as yet Gangrene is of slow evolution In a great many cases, there was a complete disappearance of pain directly after operation the ulcers cicatrized and the arterial pulse reappeared But remote observations show that the improvement was only transient A minimum of two years during which symptoms do not appear is needed before one may speak of cure Applying this test, the author found only 3 cures in 112 cases and even here it could not be proved that the cures resulted from the operation Com-

37 Samuels, Saul S Value of Oscillometry in Study of Circulatory Disturbances of Extremities, *J. A. M. A.* **88** 1780 (June 4) 1927

38 Seneque, J *Presse med.* **35** 100 (April 9) 1927



coughed up by some of the experimental dogs as soon as the effect of the ether narcosis had diminished. The results of these experiments will be reported in a later paper.

#### COMMENT

The ability of the alveoli, bronchi and trachea to exscavenge themselves of infectious material seems to have received insufficient attention in the experimental studies in the production of abscess of the lung. How do the lungs keep their air passages clean? The bronchioles and alveoli end blindly, yet they are surprisingly clean. The stomach has hydrochloric acid which aids it to cope with bacteria that may enter it. No such chemical defense is known to exist in the lungs, however, bacteria do not manifest themselves readily in their air passages. Agglutinins, opsonins and other antibodies are not known to be present in the tissue of the lungs in unusual amounts.<sup>11</sup>

Three methods may serve to cleanse the air passages. The first, and perhaps the most effectual for large masses of foreign material, is the explosive expulsion of air and solid material during a cough. Even though there is little or no air in the alveoli beyond the foreign material, the elasticity of the surrounding air-containing lung is conducive to a squeezing out and an emptying of the nonair-containing portions during the act of coughing. The second factor in cleansing the air passages is the action of the ciliated epithelium. The ciliated epithelium may carry material to the pharynx, where it is unconsciously disposed of by swallowing. Undoubtedly, bacteria and pus may be expelled from the bronchi and trachea by the cilia lining them. A third factor in the removal of solid material from the lungs is the wandering cells of the blood stream.

In addition to these three methods of removal of foreign material from the air passages, the rôle played by posture may be mentioned. The use of iodized oil 40 per cent for diagnostic mapping of the bronchi demonstrates the facility of movement of fluids to the dependent portions of the air passages.

My co-workers and I do not wish to doubt the possibility that abscess of the lung may be due to the lodgment of infectious emboli in the radicals of the pulmonary arteries. We have produced such abscesses experimentally. We have, however, hoped to point out and to prove experimentally that the route of entry of the infectious material into the lungs may be through the air passages. A single infectious embolus, when entrapped in the pulmonary artery, may produce a single abscess of the lung, likewise, infectious material entrapped in the air passages

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<sup>11</sup> Kendall, I. A. Personal communication to the author.

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## CLINICAL STUDIES

Eighty-four consecutive cases of nontuberculous abscess of the lung constitute the basis of this study. Only the significant factors which seem to have relation to their etiology will be recorded here.

Briefly, nineteen, or 22 per cent, of these eighty-four cases of abscess of the lung followed tonsillectomy. The onset of symptoms varied in these cases from three to fourteen days after tonsillectomy. One case followed tonsillitis without tonsillectomy. Five cases, or 6 per cent, followed abdominal operations. On two of these patients an appendectomy was performed, on two a cholecystectomy and on one a gastroenterostomy. All of these patients were operated on under general anesthesia. One abscess of the lung followed mastoidectomy, one followed amputation of the leg and one followed resection of the tongue for carcinoma. The three last operations were also performed under general anesthesia. In all there were twenty-seven cases, or 32 per cent, the onset of which followed closely after an operative procedure. Each of these twenty-seven patients had had a general anesthetic with unusual opportunity for aspiration of infectious material. The onset of symptoms was delayed for several days, usually from six to eight days, after the operation and the administration of the anesthetic. Abscesses produced by experimental aspiration showed a similar latent period after injection of the infectious material into the bronchus.

In each of the patients on whom operative procedures had been performed preceding the development of the abscess of the lung, there was unusual opportunity for the occurrence of emboli as well as unusual opportunity for aspiration of infectious material. In forty-five, or 53 per cent, of these eighty-four patients, however, the onset of the symptoms did not follow emboli-producing procedures or conditions. The forty-five patients variously ascribed their abscesses to previous or concurrent infections of the respiratory tract, including "bronchitis," "exposure and took a cold," "pneumonia," "pleurisy," "flu" and "typhoid pneumonia." It is probable that many of the diagnoses were erroneous, and that the symptoms which led to the diagnoses were only the symptoms attendant on the development of the abscess in the lung. The abscesses in these cases (53 per cent) seem clearly to have been the result of an infection which reached the lung through the air passages, since there had not been an opportunity for the production of infectious emboli. Clinically, they did not differ from the abscesses which followed operative procedures. They usually had the similar foul odor, and there were multiple abscesses frequently confined to a single lobe of the lung. In these respects, they resembled experimental aspiratory abscesses.

# EXTRAPLEURAL RESECTION OF THE ESOPHAGUS

USE OF THE SAME INCISION AS THAT EMPLOYED  
IN MY TRANSPLEURAL METHOD

FRANZ TOREK, M.D.

NEW YORK

In resecting the esophagus for carcinoma, a thorough exposure of the esophagus is necessary as it is not sufficient to expose merely the new growth. The resection, in order to be radical, must include a good portion of the apparently uninvolved esophagus on either end of the tumor, and more room is needed to care properly for each divided end. If my method of drawing the upper stump out through the neck and invaginating the lower stump is employed—and that method is favored by many at present—much more room is needed. The required space is amply supplied in my method of transpleural approach through the whole length of the seventh intercostal space, augmented by the division of the four ribs above that space, near the spinal column.

It is universally agreed that the method referred to affords the necessary exposure and access. There are, however, differences of opinion as to the selection of a transpleural or an extrapleural approach. The advocates of the extrapleural method claim that the opening of the pleura entails certain dangers that could be avoided if the pleura were not opened, which is true. It occurred to me that it might be possible to combine the satisfactory exposure afforded by my transpleural method of approach with the advantages of an extrapleural operation as this combination is feasible. It takes somewhat longer than the transpleural method, and it remains to be seen whether the advantages of the extrapleural attack outweigh the loss of time.

## TECHNIC

The skin incision goes through the whole length of the seventh left intercostal space and continues from the posterior end of this incision upward to the third rib. It is then deepened through the muscles. In cutting down on the seventh interspace, great caution should be exercised when the intercostal muscles are reached, and this caution should be heightened to an extreme degree on dividing the internal intercostal muscle, so that the pleura may remain intact. This part of the operation, therefore, does not permit haste, the knife is to be handled lightly, and the incisions should be shallow. When the pleura has been well exposed in the seventh intercostal space, I begin to separate it from the thoracic wall. The initial steps of the separation are the most difficult. One may start with a blunt instrument like Kocher's goiter dissector, as soon as a little headway

# UNRESOLVED PNEUMONIA

## A SURGICAL ANALYSIS \*

OTTO C PICKHARDT, M D

NEW YORK

Certain old medical terms that are all inclusive have been handed down from generation to generation. They are not terms for actual diagnoses under more modern methods of investigation, but are generalizations. Indigestion, rheumatism and other conditions come in this class, and I feel that the term "unresolved pneumonia" could be included in a large majority of cases. While undoubtedly there is such a condition, it is comparatively rare, and the diagnosis of unresolved pneumonia is usually a confession of failure to make a correct one. One has only to view its numerous synonyms commonly used to see how loosely the same condition is variously labeled. Among these may be mentioned interstitial pneumonia, chronic fibrous pneumonia, organizing pneumonia, protracted pneumonia, persistent pneumonia delayed resolution and, finally, basal fibrosis. The first three have a distinct pathologic picture which has often been described, and there can be no objection to them when correctly applied. Unfortunately, this is rarely the case.

MacCallum<sup>1</sup> stated

Occasionally, while the symptoms of the acute illness (pneumonia) disappear completely and the convalescence seems complete, a form of consolidation of the lung persists and is found to be due to a replacement of the exudate by fibrous tissue (fig 1).

Rohdenburg described the microscopic picture as follows

The lung alveoli are more or less completely filled with a meshwork of fibrin in which are entangled round and plasm cells. These wandering cells in many areas are transformed into connective tissue cells and slowly the alveolus instead of being an open space bounded by a lining of endothelium is changed to a mass of more or less dense connective tissue surrounded by endothelium.

Pneumonia, either lobar or lobular, is an acute disease, and the concept of its becoming a chronic condition in itself is rather difficult to understand. It seems more reasonable that there are, or may be, other contributing factors which will make it chronic. A new formation of fibrous tissue occurs, so that the lung becomes indurated, leathery and

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\* From the Department of Surgery, Lenox Hill Hospital

1 MacCallum, W G. Text-Book of Pathology, Philadelphia, W B Saunders Company, 1921, p 544

liberation of the entire esophagus, its division below the tumor, invagination of the lower stump, extraction of the esophagus through an incision in the neck and its transplantation into a subcutaneous antethoracic channel. The method of closure, likewise, is identical with that employed in the transpleural operation.



Fig 1—Roentgenographic appearance of the site of the carcinoma of the esophagus

#### APPLICATION OF METHOD

Thus far, I have not had a favorable case—in fact, I have completed the operation in only one case (fig 1), the others being merely explorations, as the tumors, after exposure, proved to be inoperable. In the case in which I performed the operation and in which the patient died on the fourth day, the tumor was situated behind the aortic arch, extending both above and below it. To release it some thoracic

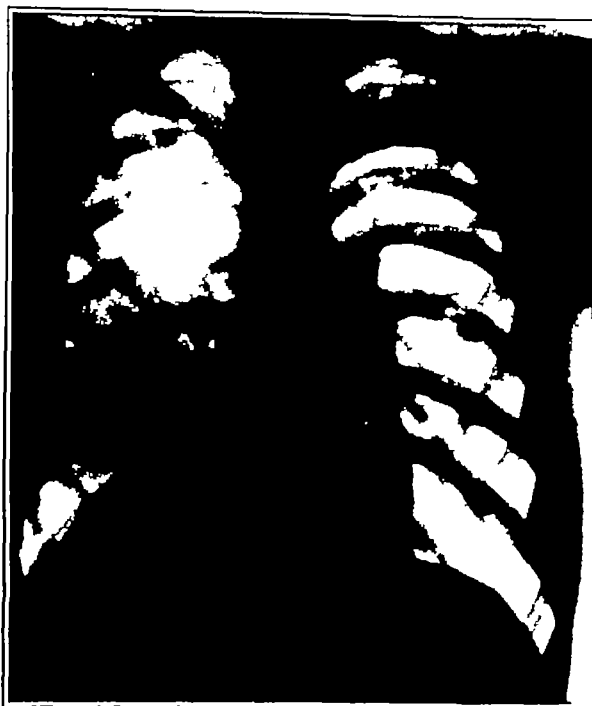


Fig 2 (case 1, table 3) —Unresolved pneumonia in the lower lobe of the right lung twenty-three days after onset

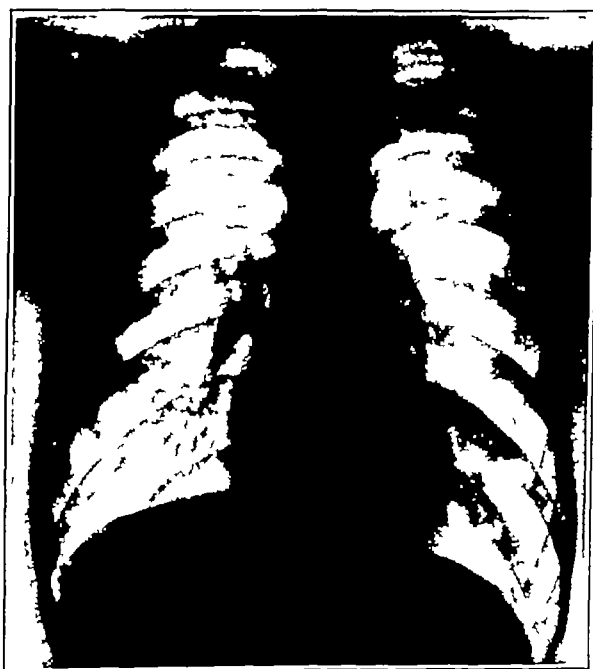


Fig 3—Same case as in figure 2 six years and three months later showing chronic peribronchial infiltration in the same area

An interesting fact connected with this case is the observation, with the aid of roentgenograms taken on the second day after operation, that there was no exudate in the pleura on the left side, the side on which the operation had been performed, but that the right side presented a haze with the evidence of an effusion (fig 2). The extensive handling of the left pleura from its outer side, without opening it did not disturb the normal transparency in the lung picture, whereas on the right side, which was simply opened but not otherwise handled, the haze of a beginning exudate appeared.

At autopsy the left pleural cavity was found to be free from adhesions and contained neither blood nor any other exudate. The pleura was tightly adherent at its parietal attachment to the ribs. The right pleural cavity contained about 500 cc of blood-stained serum. There was some fresh fibrin on the surface of the right lung. The left lung showed slight edema. Metastases were found at the junction of the esophagus and cardia in the shape of several islands of white, firm tissue, and at the upper edge of the pancreas as a circumscribed pinkish nodule, 2 cm in diameter, the microscopic diagnosis at both places being secondary squamous cell carcinoma. The primary tumor was a squamous cell epithelioma of the esophagus, 8 cm in length, showing a complete annular involvement. The lumen was completely obstructed for 5 cm.

Two months elapsed between gastrostomy and operation in this case, owing to the fact that the patient insisted on going home after the gastrostomy. The metastases helped to lower his resistance. While it is possible that they may have been overlooked at the time of the gastrostomy, in spite of careful search, they may also have arisen during the long delay between operations.

Those who have looked with favor on the advantages of the complete exposure afforded by my method of transpleural resection of the esophagus, but who, at the same time, would prefer to proceed by an extrapleural route, may perhaps be sufficiently interested in this method of extrapleural approach to give it an extended trial.



reaction which does not subside in normal fashion, and which is therefore erroneously labeled unresolved pneumonia

In 1913, Thacher<sup>3</sup> read a paper on this diagnosis and made an interesting report. He set a time limit of seventeen days during which a condition could rightly be called unresolved pneumonia. He analyzed thirty-four cases as follows: fourteen simple, mild trailer cases ending in recovery, six cases with miscellaneous complications, nine cases complicated by empyema, two cases complicated by abscess of the lung and three cases of probably simple delayed resolution. He stated

All patients, who, after pneumonia, are quite ill with a prolongation of fever, more are suffering from the presence of pus in the pleura or the lung, than from any other abnormal condition



Fig. 6—Same case as in figure 4 sixteen months later showing the peribronchial thickening in the lower lobe of the left lung

The examining physician should therefore keep in mind the pathologic differences between a real organizing pneumonia and the clinically similar but pathologically different picture presented by a patient in whom consolidation persists after pneumonia.

It is my purpose in this analysis, first, to present the many different types of lesions, both pulmonary and miscellaneous, which were actually found on closer investigation, and secondly, to show that in the rare positive case (six out of fifty-two), a definite type of lesion is found by means of the follow-up roentgenograms taken from sixteen months to

3 Thacher, J. S. Unresolved Pneumonia, *M. Rec.*, January, 1914

the feet 4 Throughout the operation ether is given in amounts sufficient to keep the patient quiet, but never to the point of an abolition of the swallowing reflex 5 The assistant is required to operate the suction tube and to keep the pharynx absolutely clear of mucus and blood 6 All bleeding vessels are ligated, and the operation usually requires the administration of ether for from thirty to forty-five minutes It is to these precautions, and particularly to the light anesthesia, that we ascribe the absence of postoperative infection of the lung in our cases If infected emboli are the cause of abscesses of the lung after tonsillectomy, it seems likely that this complication should have occurred in our cases with the same frequency that it has in some other clinics

In 1924, we began the study of experimentally produced abscess of the lung in dogs for the following purposes 1 To produce a chronic suppuration of the lung that was limited to one lobe and not complicated by pneumonia or empyema 2 To compare the blood pressure in the pulmonary artery in normal dogs with that in animals with a chronic suppuration of the lung 3 To determine the effect on the heart of ligation of the pulmonary artery and vein to one lobe in normal dogs, and to compare it with that observed in animals with a chronic abscess of the lung 4 To try various methods of removing the infected lobe and closing the bronchial stump The first two years of this investigation were occupied by the attempt to produce a chronic abscess of the lung During the past year, we have attained our first objective, but we have not yet carried out the remainder of the program By introducing through a bronchoscope a small piece of cotton saturated with fresh scrapings from pyorrhea cavities in patients, we finally succeeded in producing a chronic lung abscess that remained localized to one lobe and was not associated with a general pneumonitis These pyorrhea scrapings were swarming with spirochetes and other bacteria, but we have made no attempt as yet to isolate the organisms and to determine whether any one type was chiefly responsible for the infection in the lung In eight animals, an abscess of the lung with cavity formation and necrosis of an entire lobe was produced by direct inoculation of the main bronchus of the lobe through a bronchoscope Abscess of the lung developed in a lower lobe of two additional animals, after introduction into the frontal sinus of a piece of cotton soaked with fresh scrapings from a pyorrhea cavity in a patient Bronchoscopy was not performed on these two animals The frontal sinus was opened through an external incision, the infected pledget of cotton was placed in the cavity through a small burr opening, and the wound was closed Both of these animals developed a suppuration in the frontal sinus with the constant discharge of foul-smelling pus from the nostril, and both died from pulmonary hemorrhage after six weeks The hemorrhage was due to the erosion of a large blood vessel in the abscess cavity This experiment indicates that

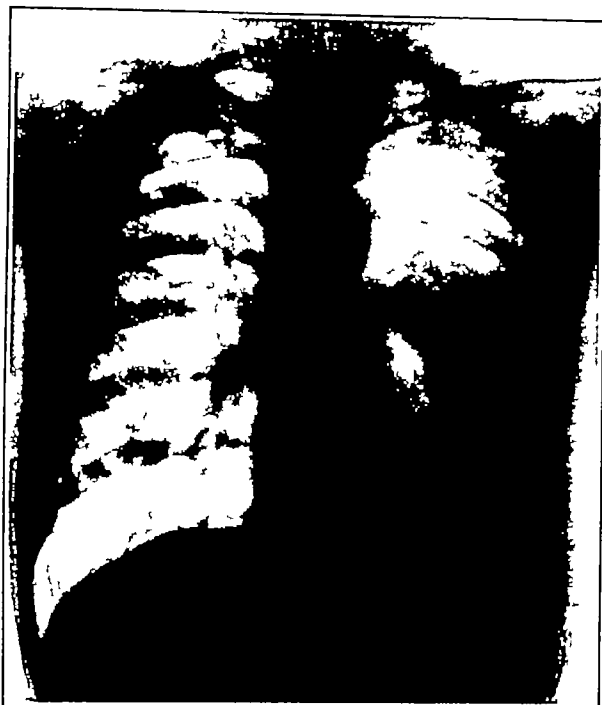


Figure 9

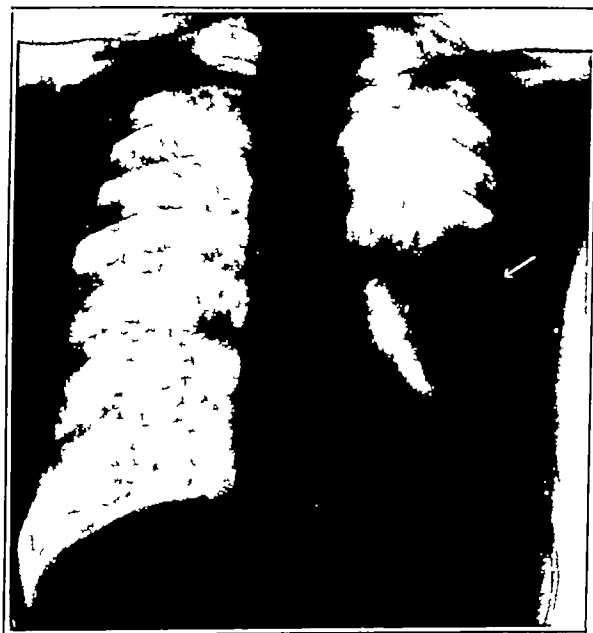


Figure 10

# ETIOLOGY OF ABSCESS OF THE LUNG

## EXPERIMENTAL AND CLINICAL STUDIES \*

DUFF S ALLEN, M D  
ST LOUIS

The causative factors of nontuberculous abscesses of the lung are not fully known. How does the infection reach the lungs? Are there specific bacteria? Why does one person develop an abscess of the lung after a certain operative procedure while another person does not acquire such an abscess after an apparently identical procedure? This is a report of the experimental production of abscesses of the lung by aspiration, and the translation of these experimental observations into some of their clinical correlatives.

### ROUTES OF ENTRY

There are three possible routes of entry for the infection in abscess of the lung. The first is direct, by way of the respiratory passages; the second is indirect, by way of the blood stream, and the third is by way of the lymphatics. The direct aspiratory route and the indirect route through the blood stream have seemed the most probable routes of entry.

A considerable percentage of abscesses of the lung follow operative procedures within the mouth, nose or throat. For these, at least, the question of whether the chief route of entry for the infection is through the blood stream or whether it lies through the respiratory passages is of the utmost importance.

If the infection reaches the lungs through the air passages, then the incidence of abscess of the lung following tonsillectomy or other operations about the upper respiratory tract and mouth might be lowered materially by the avoidance of aspiration of infectious material at these operations. If, on the contrary, the infection reaches the lungs through the blood stream as infectious emboli and not by aspiration, then the amount of aspirated blood or other infectious material that may be sucked into the lungs during these operations is of little consequence for postoperative abscess of the lung.

If the embolic route is the principal route of entry, the surgeon should direct his attention toward the prevention of dislodgment of infectious emboli. If the aspiratory route is the chief route of entry, the surgeon should prevent aspiration of infectious material. Furthermore, the spontaneous development of nontuberculous abscess of the lung might be avoided by proper attention to oral hygiene and hygiene of the upper respiratory tract and to pathologic processes in these areas.

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four years later. This lesion may be expressed as being a peribronchial infiltration and thickening due to increase in the connective tissue, localized in the formerly consolidated area. The picture is similar to that seen in a chronic bronchitis, except that in the latter the condition is found generalized throughout the whole bronchial tree (cases 1, 10, 44, 48, 52, table 3).

In order to get at a definite basis, it was decided to go through the request slips for roentgen-ray examination of the Lenox Hill Hospital and to pick out those on which had been written "unresolved pneumonia." Between January, 1922, and December, 1926, there were 2,773 requests for roentgen-ray examination of the chest for twenty-one different pulmonary and bronchial conditions, conditions of the heart were excluded



Figure 13

Of these, 591 mentioned the word pneumonia and forty-one "unresolved pneumonia." In addition, eleven cases were added through personal communications. It is to be remembered that the staff at the Lenox Hill Hospital has been among the pioneers in employing surgical procedures for conditions of the lung, and many cases of undiagnosed conditions of the lung have been received for study. Many of these patients are sent to the hospital with the diagnosis of "unresolved pneumonia," and therefore are sent to the roentgen-ray department.

In this series, cases are not considered in which the normal pneumonic crisis or normal resolution has not had time to occur, say up to the ninth day, and which have erroneously, merely from a standpoint of time, been designated unresolved pneumonia. In a general review of other cases reported in the literature, I did not find any definite time limit in which a case of pneumonia became unresolved. Frequently

succeeded in producing acute abscesses with formation of a cavity by the introduction of a single embolus into the pulmonary circulation. They failed to produce aspiratory abscess of the lung, and, therefore, concluded that most abscesses of the lung in the human being were embolic rather than aspiratory in origin. They consider this to be especially true in those cases of abscess of the lung that follow operative procedures. They agree with Fetterolf and Fox,<sup>12</sup> who believe that most abscesses of the lung following tonsillectomies are due to emboli dislodged from the paratonsillar tissues.

#### EXPERIMENTS

Acute nontuberculous abscess of the lung was produced in dogs both by the liberation of emboli into the femoral vein and by the intrabronchial injection of pus from chronic nontuberculous abscesses of the lung. For the sake of brevity, only the latter experiments, in which abscess of the lung was produced by the intrabronchial introduction of pus from subjects with abscess of the lung, will be reported here in detail. This group of aspiratory abscesses of the lung is a most important feature of this report.

**SERIES I**—Experiments in fifteen rats make up this series. Pus was obtained from cases of chronic, nontuberculous abscesses of the lung. The patients were requested to cough and expectorate the pus into a sterile cup over a period of several hours. The infectious material was then slowly introduced into the exposed trachea of the rat by the method suggested by Smith. Not a single rat developed an abscess of the lung or pneumonia.

The most probable explanation of the failure to produce infection in the lungs of these experimental animals seemed to be that the pus contained only avirulent bacteria, or perhaps that the "invasive" bacteria had been killed by chilling of the pus before it had been introduced into the trachea. Smears of the pus taken at the time of its injection showed the presence of many cocci, fusiform bacilli and spirochetes. The spirochetes found in the respiratory tract in normal persons are thermolabile. They are often killed by a fifteen minute exposure at room temperature. It seemed advisable to inject the warm pus into the bronchi of animals immediately after it had been coughed up from the lungs.

The following experiment illustrates the procedure followed in experimental series II.

**SERIES II**—*History*—B, a boy, aged 17, had had a bronchiectatic abscess of the lung for the past twelve years. As much as 200 cc of pus could be coughed up at one time when the patient instituted postural drainage by leaning over a chair. As the etherized dog could not be taken into the ward of the hospital, the patient was requested to come to the laboratory. On Feb 19, 1927 a small, healthy, active, young dog was anesthetized with ether. A soft, rubber catheter, size 10

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<sup>12</sup> Fetterolf, G, and Fox, H. The Reaction of the Para-Tonsillar Tissue to Tonsillectomy. A Study in the Etiology of Post-Tonsillectomy Pulmonary Abscess, *Am J M Sc* **166** 802, 1923

cases have been so designated in which the patients have not had time to become well either by crisis or by lysis. The average time between the onset and the tentative diagnosis in the cases here reported is fifty-five days, varying between fourteen days to one year.

One can readily understand how, except in a few cases, the diagnoses in table 1 were lumped into one grand group of "unresolved pneumonia," when one remembers that many of these patients lived where there were

TABLE 1—*Summary of Final Diagnoses*

Conditions	Number of Cases
Lobar pneumonia, bronchopneumonia, resolving or unresolved, but not finally checked up (see table 3)	10
Pleurisy, suppurative	7
Abscess of lung	5
Neoplasm, lungs	4
Bronchitis, acute and chronic	3
Pulmonary tuberculosis, chronic	3
Chronic pneumonia and pleurisy with effusion	2
Pleurisy with effusion	2
Pleurisy, serofibrinous	2
Tuberculous pneumonia, acute	2
Pulmonary tuberculosis and abscess of lung (pneumococcus)	1
Bronchiectasis	1
Neoplasm, pleura	1
Foreign body, bronchus	1
Pertussis	1
Mediastinal tumor, Hodgkin's disease	1
Abscess of liver	1
Subdiaphragmatic abscess	1
Anemia, pernicious	1
Arthritis, chronic, shoulder	1
Osteomyelitis, femur, acute	1
Pyelitis	1

TABLE 2—*Classification According to Types*

Conditions	Number of Cases	Percentage
Unresolved pneumonia	6	11.5
Pleurisy, suppurative	7	13.5
Abscess of lung	6	11.5
Pleurisy with effusion (various types)	6	11.5
Neoplasm, lungs and pleura	5	9.6
Pulmonary tuberculosis	5	9.6
Bronchial system	4	7.7
Foreign body	1	1.9
Miscellaneous	12	23.1
Frankly Surgical Conditions		
Types 2, 3, 5, 8	19	36.5

no hospital facilities for the taking of roentgenograms or the performing of a bronchoscopy.

If one adds together the cases of suppurative pleurisy, abscess of lung, neoplasm, and foreign body, one has a class of cases amounting to 36.5 per cent which at some stage of their development were frankly surgical conditions. This excludes pleurisy with effusion in which simple aspiration is usually sufficient and the various types of tuberculosis, many of which are now being successfully helped by operation.

Table 3 shows a more detailed analysis of all the cases which superficially were apparently unresolved pneumonia. On checking these up

This experiment of injecting warm, fresh pus from nontuberculous abscesses of the lung into the bronchus was repeated in seventeen dogs and three rabbits, making a total of twenty-one experiments in series II. Only three dogs developed abscesses of the lungs. The remaining fifteen dogs did not develop either abscess of the lungs or pneumonia. Roentgenograms were made and auscultation was performed repeatedly over a period of two months. The animals remained active and did not show signs of abscess. One rabbit developed pneumonia and died at the end of twenty-four hours. The remaining two rabbits lived and did not show signs of abscess at the end of fifty-two days.

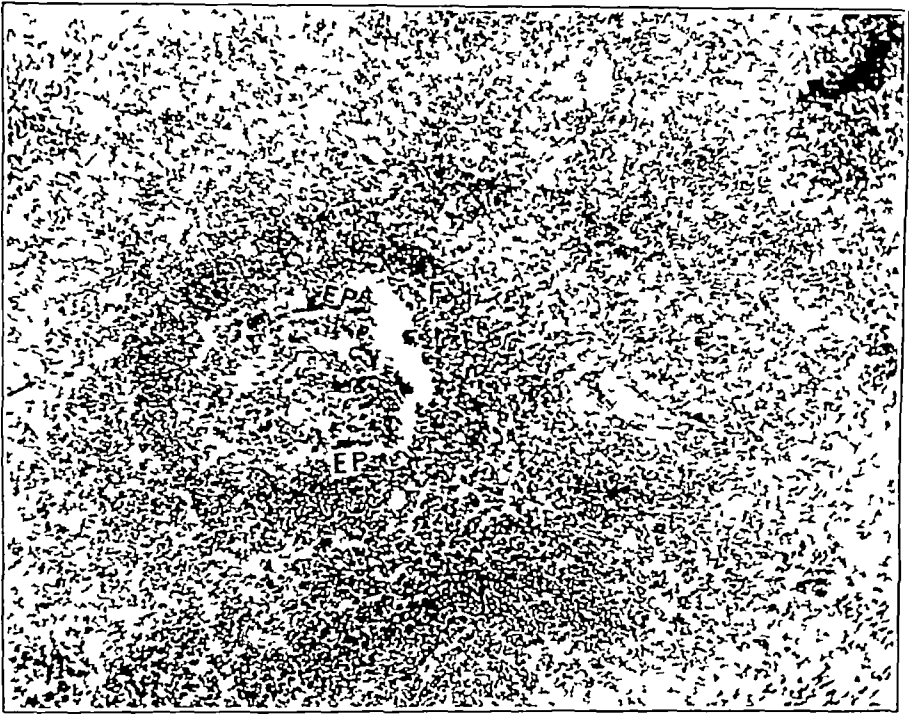


Fig 1—Erosion of epithelial lining of bronchiole due to infectious process. The fibrous tissue ring, *F*, of the wall is intact. Epithelial casts, *Ep*, can be seen clinging to the fibrous tissue. Bacteria were not found in the walls of the blood vessels or in their contents. Bacteria were seen throughout the wall of the bronchiole and the surrounding tissue.

The three dogs in which multiple abscesses of the lung developed after aspiration of pus from abscess of the lung are of special interest. For the sake of brevity, the two latter experiments will not be described in detail, as I have described the first. After intrabronchial injection of pus, the dogs all exhibited a latent period before the onset of malaise. None of the three animals was observed to cough, though all of them had pus in the trachea and bronchi at necropsy. None of the three had an abscess with a cavity. The condition in the dogs therefore resembles the usual early abscess of the lung as it appears



carefully, I find that only six of ten can honestly be so classed, the other four must fall into the miscellaneous group. In this connection, it is interesting to note that whereas apparently definite signs of consolidation were found by physical examination of the lungs, the roentgenograms were negative for such a condition. According to this analysis of fifty-two cases, in only six, or 11.5 per cent, was the diagnosis of unresolved pneumonia correct. It seems as if the fallacy of this tentative diagnosis is being continued, and that therefore a more detailed and comprehensive study of this type of case is necessary before such a diagnosis can finally be made.

The internist can expect and should seek a more definite diagnosis in this class of usually undiagnosed pulmonary conditions by consultation with the bronchoscopist, the roentgenologist and the thoracic surgeon. The thoracic surgeon should be consulted with a view to curing by operation a large percentage of patients with a hitherto anomalous medical condition.

#### CONCLUSIONS

- 1 True primary unresolved pneumonia is rare
- 2 In the rare positive case, a definite localized peribronchial infiltration, visible in the roentgenograms, develops later
- 3 Approximately 36.5 per cent of pulmonary conditions diagnosed as unresolved pneumonia will be frankly surgical conditions
- 4 The thoracic surgeon should be consulted more frequently when pneumonia does not resolve promptly and properly

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Attempts were made to entrap bacteria in the alveoli and smaller bronchi. It seemed that the formation of an abscess or some other manifestation of an infectious process would inevitably follow the confining of bacteria in the smaller air passages. Slugs of infectious tonsil and small pieces of beef contaminated by virulent bacteria were blown into the bronchi with compressed air. Abscesses did not develop in seven experimental dogs. Autopsy invariably showed that these infectious materials had escaped from the bronchi. The great difficulty in keeping infectious material in the air passages was soon evident.

Warm pus obtained from a patient with a foul, chronic abscess of the lung was next injected into the bronchus leading to one lobe, after which this bronchus was immediately ligated with silk. The procedure is illustrated in the following experiment.

**SERIES III—History**—On April 2, 1927, under ether narcosis, artificial respiration was maintained by the Gesel-Erlanger intermittent positive pressure artificial respiration apparatus. The dog was placed on its left side. An intercostal incision was made between the fourth and fifth ribs in the right side of the chest. The bronchus to the middle lobe was exposed by isolation of its accompanying pulmonary artery and pulmonary vein. The middle lobe was carefully avoided in this procedure in order to prevent injury to its alveoli. A stout silk ligature was passed beneath the pulmonary artery and vein to the lobe and carefully carried around the bronchus to encircle it completely. A soft rubber catheter of small caliber (no. 10 French) was now passed into the trachea by an assistant, and when the end of the catheter was felt to enter the bronchus to the middle lobe of the right lung, 3 cc. of the warm pus was injected into the bronchus, and the ligature was immediately tightened as the catheter was withdrawn. The wall of the chest was then closed without drainage.

April 3. Some dyspnea was present, but the dog was active and ate.

April 5. The dog was active, and did not appear to be sick.

April 7. Swelling appeared about the thoracotomy wound. The dog frisked about the room when he was taken from the cage.

April 10. The dog was sick, hung his head and coughed (this was the only dog which coughed). *Foul pus dripped from the nostrils.*

April 11. The thoracotomy wound was open. When the dog coughed, air gushed from the wound, but did not seem to enter the chest through the wound. The dog appeared to have bronchial fistula.

April 15. The thoracotomy wound was closed. The animal still coughed, appeared listless and was losing weight.

April 21. The dog coughed. Chocolate colored, foul-smelling pus dripped from the nostrils.

April 25. The dog was more active, but had lost a great amount of weight. He coughed but did not expectorate pus.

April 28. The dog was weak and emaciated. He was fairly active and did not have pain. To avoid the possibility of suffering due to extreme emaciation the dog was killed.

**Autopsy**—The thoracotomy wound was closed with granulation tissue. The left side of the chest did not contain fluid or pus. The left lung appeared normal. The mediastinal lobe was lying free in its mediastinal pocket of the pleura.

# NONTUBERCULOUS PULMONARY SUPPURATION

## A COMPARISON OF OPERATIONS AND THEIR RESULTS

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NEW YORK

The scientific selection of operative therapy in pulmonary suppuration is still in a state of development. Standardization is often a poor principle when applied to any phase of surgical work except the technic, and possibly even here it is particularly out of place in dealing with conditions the pathologic anatomy and biologic status of which show such fine distinctions as do those encountered in suppurative infections of the lungs. The frequent complication by disease of other structures, particularly of the pleura, adds still another problem to this perplexing question.

I need not discuss an exact classification of the various types of suppuration, although the blood-borne and the air-borne sources—the one beginning in the parenchyma of the lung and the other beginning in the bronchial tree and its ramifications—may roughly be recognized. To these may be added infection from contiguous structures. When changes related to the stage of the process and the organism which produces the infection are also recognized, one finds that confusion ensues. Going farther, varied anatomic characteristics in different portions of the same diseased organ are encountered. It must also be realized that in the lung one form of suppurative disease almost invariably produces another, such as abscess developing from bronchiectasis.

Few, if any, surgeons have had sufficient experience with all of the methods of operating in these diseases to confer authority. One operator may have been fortunate in the immediate results of bronchostomy, another may be satisfied with destruction by cautery, still another may have faith in some form of compression, and so on. Until one procedure has been used in many hundreds of cases of approximately the same condition, improvement in the methods of operation will be made slowly. All those who have had experience should record their results, for with the accumulation of evidence, the right technic may finally be approached. This is the reason why I present the conclusions which I have reached from my own clinical work.

The material examined consists of 105 unselected patients who were referred to me for operation and in whom lobectomy was neither performed nor contemplated. The list of conditions includes most of the forms of surgical pulmonary suppurative disease with the exception of tuberculosis and actinomycosis. I have also excluded the military cases and those of civilian traumatic surgery.

lobe They were identical in appearance to the spirochetes found in the tonsil which had been insufflated into and trapped in the bronchus

The experiment was repeated with a mixture of virulent streptococcus, staphylococcus, colon bacillus and pyocyanus The animal died on the fourth day of pneumonia of the right upper middle and lower lobes and beginning empyema of the right pleural cavity

Four control experiments in dogs in which the bronchus to the middle right lobe was ligated without the intentional introduction of infectious material into the bronchus failed to develop abscess This, and the fact that following the aspiration of pus-containing fusiform bacilli and spirochetes, the abscesses of the lung in animals with liga-

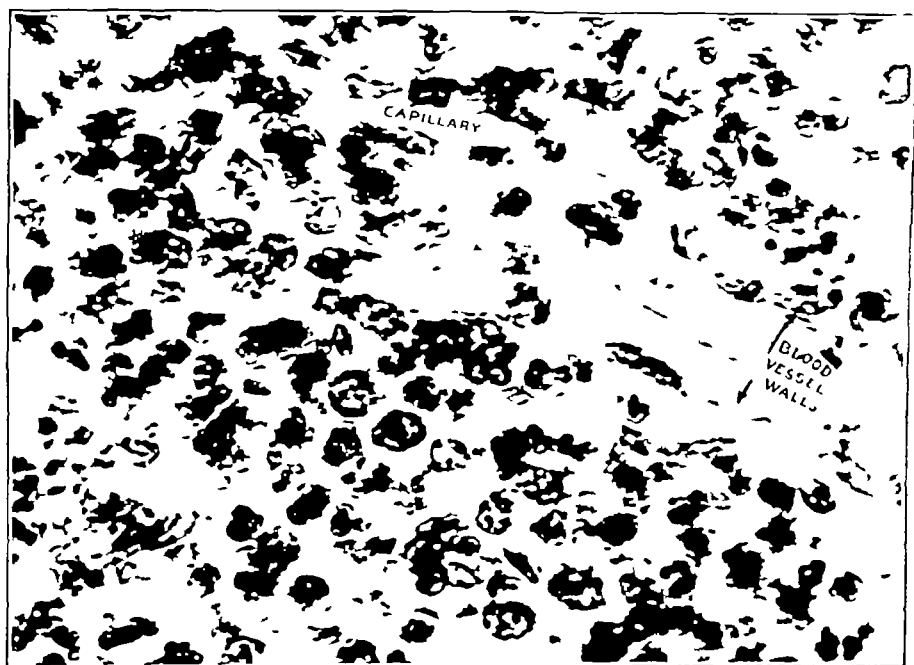


Fig 3—Intact capillaries in an aspiratory abscess The stained section showed the capillaries filled with intact red blood cells

ture of the bronchus contained identical bacteria seemed to show that blocking of the respiratory passages was an important factor in the production of these abscesses

Less complicated methods than ligation of the bronchus to a lobe to produce obstruction are being tried Siebert<sup>13</sup> had produced this blockage by the use of talcum powder before the latter series of experiments was begun More recently, I introduced contaminated millet heads with the barbs pointing toward the larva This was accomplished through a bronchoscope, the millet head being placed in the smaller bronchus under the control of vision Even these grass heads were

13 Siebert W Personal communication to the author

Table 1 represents the causes of the pulmonary infections as far as I was able to assign them

In a number of cases, intranasal infection from various causes was present and sometimes was etiologic. The nose should always be examined, especially when a radical operation on the lung is planned.

There was a total of forty-seven deaths, or 45 per cent, and of these, sixteen may fairly be ascribed to septic conditions which existed before operation. By this I mean that these sixteen patients would probably have died of their disease if they had been treated medically.

In nine cases, postoperative cerebral embolic conditions were directly responsible for death. Three of these deaths were due to air embolism and the remaining six to bacterial infection. Nine patients died of

TABLE 1—*Causes of Pulmonary Infection*

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Congenital	4
Chronic bronchiectasis	2
Pneumonia, including influenza, etc	29
Syphilis	1
Diverticulum of esophagus	1
Cardiospasm	1
Puncture of the esophagus from within	1
Aspiration pneumonia not following operation	3
Nasal operation	1
Tooth extraction	1
Fracture of thigh	1
Osteomyelitis of ribs	1
Confinement	1
Cholecystectomy	1
Appendicectomy	5
Tonsillectomy	21
Hemorrhoidectomy	1
Direct extension from abdomen	1
Unknown	29
	<hr/> 105

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hemorrhage either from the wound or from the mouth or from both. There was one fatal mediastinitis. Two patients died from phlegmon of the wall of the chest produced by diagnostic puncture of abscess of the lung. Seven died of contralateral pulmonary conditions, including pneumonia, edema and abscess. In the cases of abscess, it was not always possible to differentiate between preoperative and postoperative conditions. Two patients died from shock and one from acute nephritis not present before operation.

These causes of death will be briefly discussed in order.

*Cerebral Conditions*—(a) *Air Embolism*. It is understood that this accident may result from the entrance of air into even a small branch of the pulmonary return system. As air is lighter than blood, it is manifest that the erect posture during operations or other manipulations on indurated tissue within the chest is dangerous. It is good practice, therefore, to operate in these cases with the head of the patient lower than the thorax. Air embolism from the lung is rare except as an operative accident.

may produce multiple abscesses of the lung. The principal requisite in either case is that the infectious material is not allowed to escape from the lung.

The fact that in the five experimental aspiratory abscesses of dogs each involved lobe had multiple abscesses is of the greatest clinical significance. Most patients with abscess of the lung exhibit multiple abscesses rather than a single abscess with a cavity. During the operation of cauterized pneumectomy, as advocated by Graham,<sup>15</sup> great numbers of smaller abscesses are usually encountered in the infected area of the lobe.

That experimental abscess of the lung may be produced by the lodgment of infectious emboli has been repeatedly shown. Cutler and Holman, Weidlein and Schlueter<sup>10</sup> devised a uniformly successful and ingenious method for producing such embolic abscesses by using a

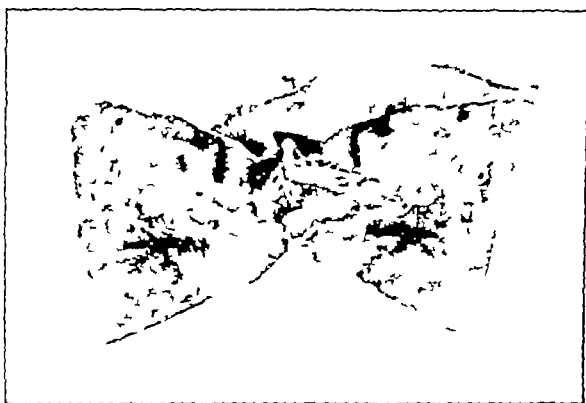


Fig. 4—Cut surface of a lobe of lung containing multiple aspiratory abscesses. Note the bronchioles in the central portions of the abscesses.

segment of vein containing various kinds of bacteria. Cutler and Schlueter<sup>9</sup> and Schlueter and Weidlein<sup>11</sup> reported a large series of experimental abscesses of the lung produced in this manner. They hold that abscesses of the lung following operations have an etiology different from those abscesses which do not follow operations. Smith<sup>1</sup> doubted this. He compiled reports of fifty-six cases from the literature in which bacteriologic and pathologic studies had been made and he did not find any difference in these respects between abscesses of the lung following operations and those in which operation had not preceded the onset of the abscess. We cannot determine whether the abscess has followed an operative procedure or not, except by questioning of the patient.

Experimental results indicate the possibility that the infection may reach the lung through the air passages in clinical abscess of the lung.

<sup>15</sup> Graham, E. A. Pneumectomy with the Cautery. *J. A. M. A.* 81:1010 (Sept. 22) 1923.

## RECOVERIES AND DEATHS

In table 2 three cases are included in which the cautery was used in the lung. In two of these, a considerable portion of tissue was destroyed. One death resulted from hemorrhage at the wound and by mouth, and one from a cerebral metastasis. In the remaining case, death followed the destruction of part of a wall of the abscess for the purpose

TABLE 2—*Percentage of Deaths and Number of Recoveries from Different Procedures, Including Clinical Cures*

Condition	Cases	Recoveries	Deaths	Percentage
Artificial pneumothorax	2	2	0	0
Thoracoplasty	13	4	5	38
Pneumonolysis extrapleural	5	2	2	40
Pneumonolysis intrapleural	2	0	2	100
Drainage	57	30	18	32
Pneumonotomy	15	3	11	73
Bronchostomy	15	7	5	33
Diagnostic puncture of abscess	3	1	2	67
Preliminary thoracotomy	2	0	2	100

of drainage. A severe hemorrhage at the wound and by mouth, during a dressing, could not be checked by packing.

My unfortunate experience with the cautery should be compared with the many excellent results reported by Graham. One cannot help being influenced by his earlier cases, but I would not attempt to deter others from using the soldering iron, perhaps I shall have better results in the future.

These figures are given for what they are worth. It would be impossible in a paper of this kind, and perhaps even in any event, to show statistically other results than those which come under the classification

TABLE 3—*Age Incidence*

Age Decades	Cases	Deaths	Percentage
1 to 10	10	3	30
10 to 20	11	4	36
20 to 30	26	12	42
30 to 40	20	6	30
40 to 50	22	12	55
50 to 65	16	10	63

of "well," "clinical cure" or "death." I shall, therefore, not attempt to record them otherwise than under the headings of "deaths" and "recoveries," including "well" and "clinical cure" under "recovery." By clinical cure, I mean that the patient was able to work and was satisfied with his condition.

Age as a factor is represented in table 3.

The danger of increasing age is, therefore, represented as follows. In patients up to 50, the mortality was 42 per cent, while from 50 to 65 it was 63 per cent—a matter of interest principally with regard to prognosis.

The remaining eleven abscesses of the lungs in this series of eighty-four were distributed as single instances, the onset of which followed respectively, aspiration of bone from a pork chop fracture of rib craniotomy, carcinoma of the esophagus, postpartum metritis, severe trauma with fracture of the leg, paranephritic abscess (?), empyema in which a rubber tube had been lost after thoracostomy, empyema and infection of a tooth, one was a primary carcinoma of the lung with abscess. Conclusions should not be drawn from these isolated instances of abscesses of the lung.

There can be but little doubt that much infectious material reaches the smaller air passages, not only during operative procedures about the upper respiratory tract, but during general anesthesia and in ordinary breathing. Myerson<sup>16</sup> examined the trachea and larger bronchi in 100 cases following tonsillectomy. Blood was present in seventy-nine instances. Lemon<sup>17</sup> found that in dogs under ether narcosis, materials which had been placed in the mouth could be recovered from the smaller air passages. The intrapharyngeal instillation of iodized oil into the trachea, first successfully used by Singer<sup>18</sup> illustrates the ease with which the contents of the pharynx may reach the lungs during ordinary inspiration. Why, then, is not abscess of the lung a more common disease?

The experiments have shown the ease by which infectious material escapes from the bronchi and trachea. In addition I should like to point out the fact that the air passages are normally lined with an unbroken epithelium. They are, in reality, a part of the "exterior" of the body. The experiments show that the lining epithelium may be destroyed by certain bacteria confined within the smaller air passages. Abscesses are then formed within the lung.

#### CONCLUSION

1 Multiple abscess of the lung may be produced in dogs by the injection into the bronchus of warm pus from patients with chronic abscess of the lung. The dogs, in the experiments described were under ether narcosis at the time of contamination of the bronchus.

2 Clinical abscesses of the lung are usually multiple and are often confined to one lobe.

3 Obstruction of the bronchus plays a dominant role in the formation of experimental aspiratory abscess of the lung.

16 Myerson, M. C. Pulmonary Aspects of Tonsillectomy under General Anesthesia, *Laryngoscope* **32** 929, 1922.

17 Lemon, W. S. Aspiration. Experimental Study. *Arch. Surg.* **12** 187 (Jan.) 1926.

18 Singer, J. J. Bronchography. *Arch. Surg.* **14** 167 (Jan.) 1927.



interstitial, true general drainage is almost impossible, but after incision, I have seen the indurated tissue break down and slough away

*Bronchostomy*—Bronchostomy is often followed by surprisingly good immediate results, but the patient's ultimate condition cannot be considered ideal. The dangers of slowly spreading gangrene with recurrent hemorrhages even years after the establishment of the stoma give a sense of insecurity to the surgeon who has encountered these late accidents

*Diagnostic Puncture of Abscess*—The performance of puncture for the purpose of diagnosis need be mentioned only to condemn it. I have observed many fatal cases in addition to those mentioned in my table and in which extensive operation for the ensuing phlegmon has been unavailing. A cure rarely results from drainage of the phlegmon and of the abscess of the lung

#### COMMENT

When one reviews the material which forms the basis of this presentation one is struck by the high mortality rate of 45 per cent in operative cases. In glancing over a paper by MacKenzie<sup>2</sup> I note that he gives the mortality rate as from 40 per cent to 80 per cent, although in 169 cases from Bellevue Hospital, the death rate was about 40 per cent. He does not make any distinction between the cases in which operation was performed and those in which it was not performed. In the same paper this strong statement is found: "When a lung abscess does not terminate fatally or in spontaneous cure, there ensues a condition of invalidism to which death itself seems preferable." The type of patients to which he refers will probably finally die either of some condition directly connected with the abscess of the lung or of the consequent chronic sepsis with or without amyloid disease. It is difficult to calculate statistics in these circumstances.

My paper has been written in order to call attention to this aspect of suppuration of the lung. If recovery is not complete, whether or not operation has been performed, the probability is that the patient will finally succumb to his disease or to its sequelae. The cases must be followed for years if one is to get at the truth and not be satisfied with mere impressions. If palliative measures alone are used, the final mortality rate will be high—approximating MacKenzie's 80 per cent, or even more. One must not be deceived by the discharge of a living patient from the hospital. Incomplete operations, on the other hand, may be expedient, though undesirable, and it is the function of the thoracic surgeon to prolong comfortable existence even though he does not lose sight of the ever present danger

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<sup>2</sup> MacKenzie, L. B. M. J. & Record **119** 191 (Feb) 1924

dry, analogous to that condition which appears in other organs, such as the kidney and the liver in chronic congestion. But this process requires time, and a constant focus of infection, a nidus of pneumococci or other bacteria, or some irritant must continue to be present, then it can readily be seen that the pathologic changes occur as a protective measure. This new fibrous tissue may occur by a slow hyperplasia of the existing fibrous tissue or by the formation of granulation tissue which gradually becomes denser with contraction. When an acute infection has either refused to subside normally or has caused apparently temporary pathologic changes which persist, with a rise in temperature and other signs, a surgeon naturally thinks that the causative agent is still present either in smaller

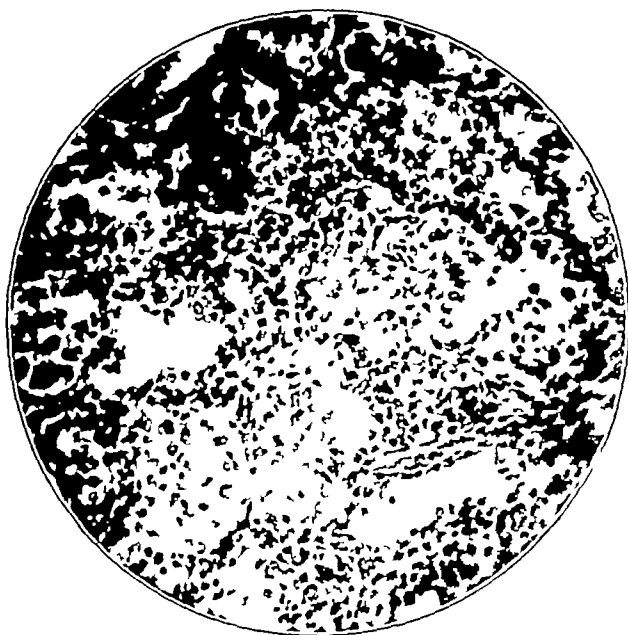


Fig. 1—Unresolved pneumonia

numbers or in an attenuated form. In other words, in the condition under discussion, a residual focus frequently remains which often forms pus either within the lung tissue or extrapleurally.

Piersoll<sup>2</sup> stated that there are two main classes of cases that are diagnosed as unresolved pneumonia: (1) true unresolved pneumonia and (2) pneumonic sequelae. I would add a third class, 'pneumonic precursors or forerunners.' In the latter class, some other primary condition is the underlying cause of the pneumonia itself, as, for instance, tuberculosis, tumor of the lung, a foreign body, bronchiectatic cavities, syphilis and other conditions. The cases in this class are more numerous than is usually thought, frequently there is a long drawn out inflammatory

2 Piersoll J. M. Unresolved Pneumonia. Penn. M. J. 25: 249, 1922.

favorably with that following much smaller operative procedures on the lungs and pleura. Granted that the early postoperative mortality is high, say 45 per cent, when only one lobe is removed, this must be balanced against mere palliation or even the so-called clinical cures of permanent bronchostomy with their chances for late fatal complications.

The more I study this question, the more I am inclined to favor lobectomy in appropriate circumstances. In the category of cases suitable for the performance of an operation, I would include only those in which the patient is under 35 years of age, and in which the blood pressure is more than 120 and the patient's general physical resistance apparently is high.

When I performed lobectomies in the earlier part of my thoracic work, I naturally chose the worst surgical risks. The mortality rate in my cases after the performance of this operation at that time was about 40 per cent when a single lobe was extirpated, and I am certain, from my experience with operations not so complete, that the statistics of ultimate cures would be on the side of the radical procedure. One is too apt to regard the mere discharge of a patient from the hospital, although he is still expectorating and usually has a permanent opening in the thorax, as representing a cure. When there is a bronchiectatic suppuration in more than one lobe, or when complications arise from previous operations, such as a dense mass of intrathoracic adhesions, lobectomy is out of the question, and one must be satisfied with far less than an ideal recovery.

#### SUMMARY

- 1 The number of cases presented is 105, all of which were operative.
- 2 Lobectomy was not performed or contemplated in any case in these series.
- 3 Tables represent operative and other statistics.
- 4 A brief comparison of these operations with lobectomy leads to the recommendation that the radical procedure should be preferred in suitable instances.

52 East Eighty-Second Street



Fig 4 (case 44, table 3) —Unresolved pneumonia in the lower lobe of the left lung sixty-three days after onset



Fig 5—Same case as in figure 4 fourteen days later The consolidation has cleared up

for two years, one in which a little cross-bar pin was present for thirteen years and one in which a tack was retained for twenty-three years.

Of the four cases in which the foreign body could be removed, i. e., the piece of wood, the tack, the pig knuckle and the cross-bar pin, recovery occurred in three. In one, suppuration persisted, and a lobectomy was performed, the patient died while he was being taken off the table.

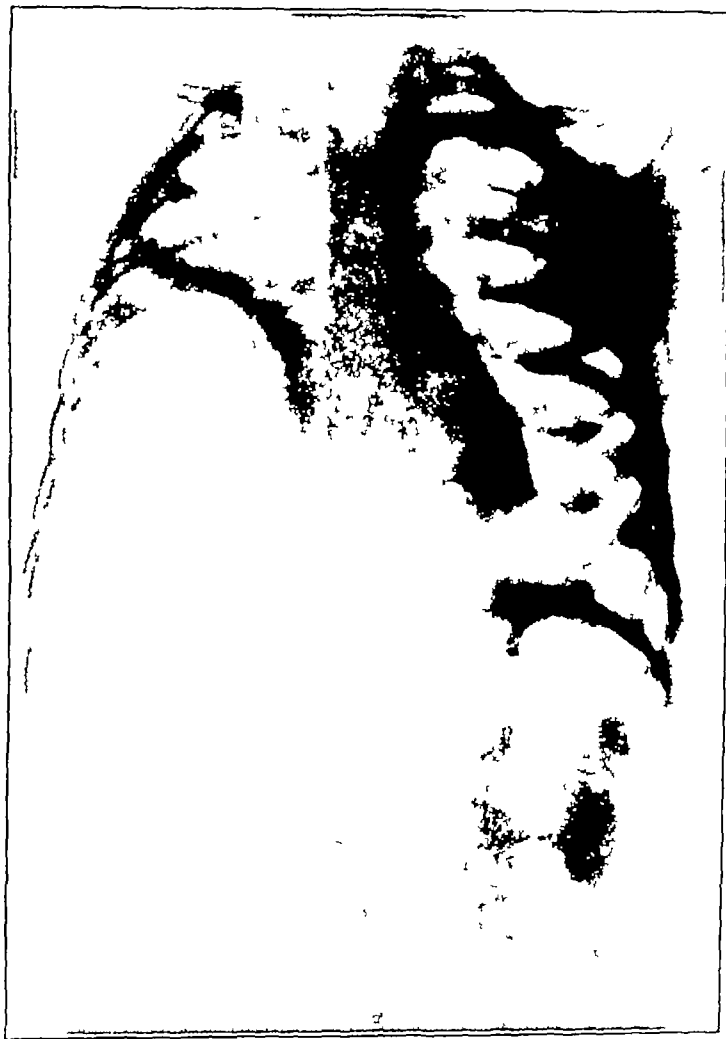


Fig 1—Abscess of the lung three weeks after operation in a child, aged 2 years.

Sixty-eight of the 103 patients were treated by bronchoscopy. Before considering treating a patient with abscess of the lung by bronchoscopy, I arbitrarily set the number of bronchoscopies as three. It usually required two bronchoscopies to get acquainted with the patient. Patients are frightened the first time, and one can only pass the tube in and out, the second time, when they are not so frightened, one can learn something, the third time, one can get results. Three



Figs 7 to 13 (case 48, table 3) —Gradual clearing up of an unresolved pneumonia through a period of ninety-seven days. A final follow-up (roentgenogram not shown here) again shows peribronchial thickening



Figure 8



Fig 4—Abscess of the upper lobe of the right lung, forty-two days after tonsillectomy

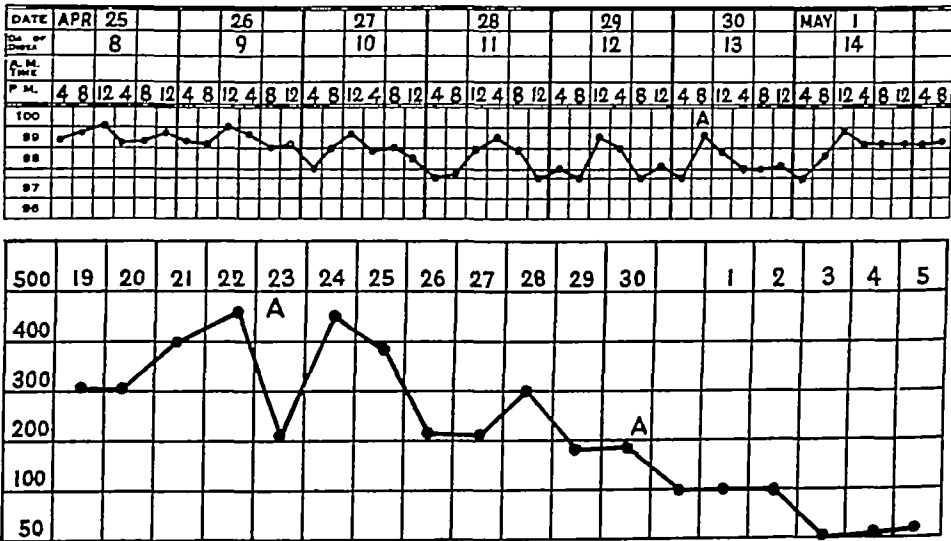


Fig 5—Temperature curve and sputum curve following bronchoscopies. This illustrates the same case as does figure 4. A indicates performance of bronchoscopy.



Figure 11

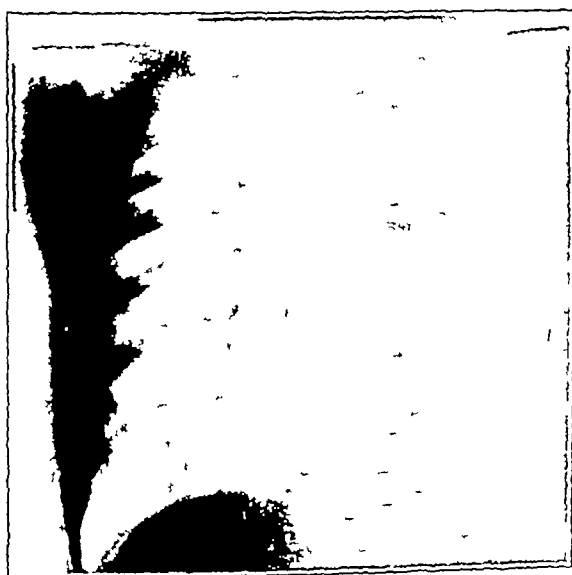


Figure 12



it is like an operation on a very ripe boil, the pus gushes out in a mass, and the situation is relieved. The patient recovered.

I had another case in which abscess of the lung developed following tonsillectomy. The patient was relieved after one evacuation of the abscess cavity. I should have been proud to have relieved him, but he did it himself. After a roentgenogram had been taken at the hospital, the patient went home to consider having bronchoscopy performed, but during an attack of coughing he coughed up the abscess.

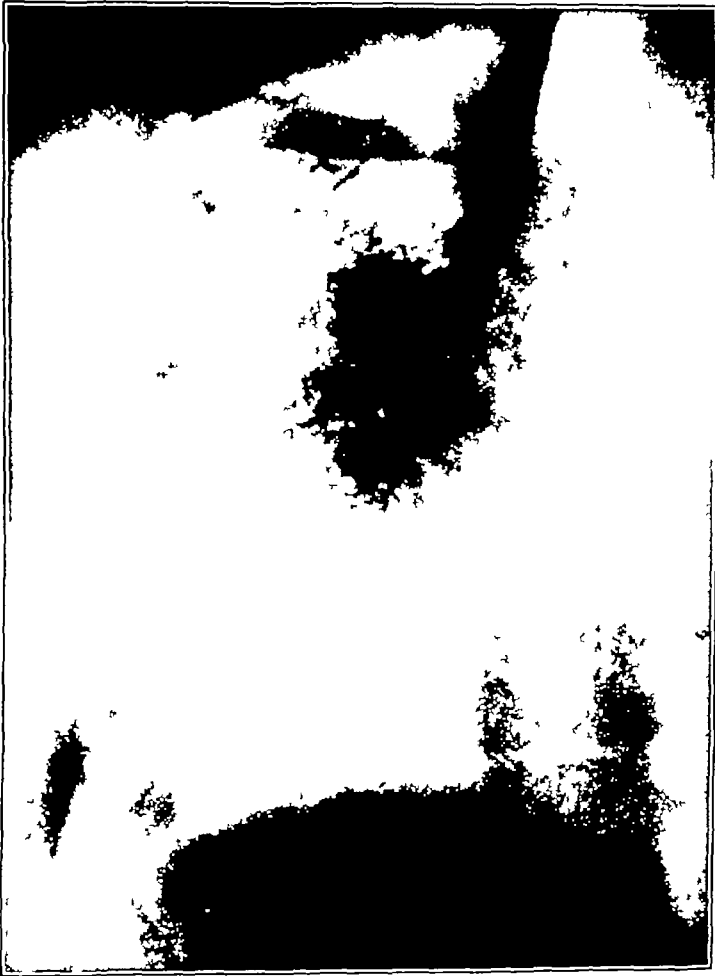


Fig 7—Effect of too much iodized oil. This illustrates the same case as does figure 6.

When he came back in two weeks, there was no trace of the abscess in the lung. Sometimes patients can be relieved by one evacuation.

The next case was one that occurred in a patient at the other end of the scale of age. A child, aged 2 years, had had a tonsillectomy performed twenty-one days before the roentgenogram shown in figure 1 was taken. A large abscess was found in the lower lobe of the right lung, without contents. Bronchoscopy was performed at once. A week after the roentgenogram was taken, rapid resolution occurred.



Fig 14 (case 52, table 3)—Unresolved pneumonia six weeks after onset  
Early peribronchial signs are seen in the lower lobe of the right lung



Fig 15—Later peribronchial signs three years and five months after onset  
of the same patient as in figure 14

The temperature curve is shown in figure 2 After bronchoscopy was performed there was some disturbance in the temperature, but then it went down to normal and the child made an uninterrupted recovery

The essential point is to treat the patients early, while there is still elasticity in the wall of the abscess cavity and chance for it to contract

The next case was that of a child, aged 9 A tonsillectomy had been performed thirty-three days before admission to the hospital, when she was admitted she had an abscess and the type of temperature shown



Fig 10—Abscess of the lower lobe of the right lung following gassing during the war

in figure 3 Bronchoscopy was performed The temperature promptly subsided to normal, and the patient promptly recovered

The probability is that these are cases for aspiration, and that the focus lies near the hilum where it can be reached with the bronchoscopic tube

The next case was that of a boy who had had a tonsillectomy performed forty-two days before admission to the hospital He was in a miserable condition, the lesion was in the upper lobe of the right lung, that is, not so near the hilum, and rather close to the periphery The

TABLE 3—Detailed Analysis of Cases of Apparently Unresolved Pneumonia

Case	Name	History Number	Clinical Symptoms (Hospital Days)	Röntgen Ray Observations	Discharge Diagnosis	Check up Diagnosis on Review of Case	To Be Classified as Unresolved Pneumonia	Follow up Röntgen Ray Observations
1	A S	1105	(Consolidation very slowly dissolving, lysis temperature normal on eighth day and hospital on seventeenth day amount of fluid	Unresolved pneumonia in the lower lobe of the right lung	Resolving lobar pneumonia	Correct	Yes	Chronic peribronchial infiltration
6	M G C	061	Distant breath sounds and decreased tactile and vocal fremitus irregular temperature	Consolidation	Chronic pneumonia and pleurisy with lobar pneumonia	Correct	Yes	
7	R B	711	High pitched false inspiratory rales temperature normal on ninth day lysis normal reaction of pulse and distant fremitus whisper absent	Absolutely no roentgenographic evidence of an unresolved pneumonia		Diagnosis unknown	No	
10	W M	27	High pitched false inspiratory rales temperature normal on ninth day lysis normal reaction of pulse and distant fremitus whisper absent	Definite persistent consolidation including whole right side from dome downward	Lobar pneumonia	Diagnosis unknown	No	
11	M K	122	Slight dullness in left base diminution of breath sound at apex in both physical signs and roentgen observations	Definite consolidation in the lower lobe of the right lung	Lobar pneumonia	Correct	Yes	Chronic peribronchial thickening
12	M W	102	Pulmonary rales at apex and base diminished basal fremitus and whisper absent	Definite consolidation as found in pneumonia	Bronchopneumonia	Diagnosis unknown	No	
13	R	1114	Consolidation changing up slowly	Consolidation as found in pneumonia	Bronchopneumonia	Correct	Yes	Negative for pulmonary pathology
14	K I	101	Roentgenogram taken 4 weeks after onset shows early post bronchial infiltration	Consolidation changing up slowly	Lobar pneumonia	Correct	Yes	Chronic peribronchial thickening in months later
15					Bronchopneumonia (diffuse)	Correct	Yes	Shows consolidation around bronchial infiltration by early 6 months later

In figure 6 the upper lobe of the right lung is shown, and the indication is that the bronchus of the upper lobe, where it entered the old abscess cavity, has been shut off by the scar tissue and the air, if it finds its way to that location, it is doing so through small collateral bronchi. In figure 7 a little more iodized oil was administered in order to fill out the cavity, and the whole picture was spoiled



Fig 12—Small postpneumonic abscess in lower lobe of the left lung

The next case was one that I consider proves the point that bronchoscopy should be performed in every case of abscess of the lung, for here seemingly was a lesion which was hopeless from the point of view of any but surgical treatment. There was interlobar empyema and abscess cavity of the lung. In spite of the gloomy outlook, the patient improved under medical treatment until the infiltration in the lung began to reappear, then bronchoscopy was performed, following bronchoscopy, the lesion diminished again, and the patient continued to improve. In March, 1926, she was clinically well. However gloomy

- Fontaine, B W Pulmonary Fibrosis, J A M A **80** 1129 (April 21) 1923
- Lederer, R Chronic Nontuberculous Respiratory Diseases of Children W er  
klin Wchnschr (supp) **37** 1 (Dec 25) 1924
- Meyer, W Chronic Pneumonia or Tumor of Lung, Interesting Observation  
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- Milan, W S Differential Diagnosis of Pulmonary Disease Minn M J  
**8** 47 (Jan) 1925
- Bissell, F S Differential Diagnosis of Certain Chronic Lung Adhesions  
Roentgenological Study, Am J Roentgenol **13** 126 (Feb) 1925
- Lyall, W L Pulmonary Fibrosis, Edinburgh M J **32** 107 (March) 1925
- McNeil, Charles Fibrosis of Bronchi and Lungs Following Broncho-  
pneumonia, Edinburgh M J **32** 152 (July) 1925

think that it was possible to cure the patient because a spiral tube could be put right into the abscess cavity. The treatment consisted of injections of a silver preparation once a week, which seemed to have a disinfecting effect and made it possible to aspirate the abscess and keep it clean. I do not believe that the patient will be altogether safe from a recurrence. I do not see how a patient could ever be completely cured when the lung was the site of suppuration for such a long time.

FRANKLIN HOSPITAL FRANKLIN N. J.  
(SURGICAL CHART)

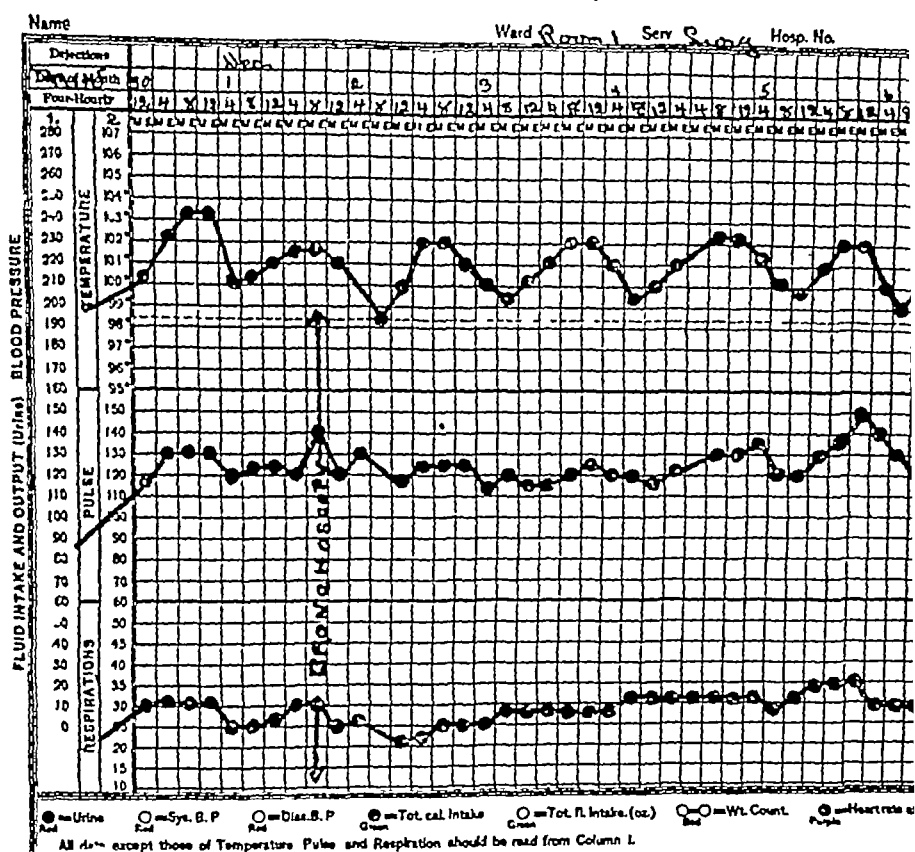


Fig 14—Temperature chart of a very sick patient showing shock before bronchoscopy

The next case is of a different type (fig 10). The patient was gassed in the war and never completely recovered his health. Before coming to the hospital, he became conscious of a dry sensation in his throat and began to cough and sweat at night. He changed his work several times, and finally went to a hospital. He was admitted in July, 1925, and a short time afterward, bronchoscopic treatment was instituted. The temperature curve and the sputum curve are shown in figure 11. A large quantity of sputum was raised, up to 1,400 cc a day. On the day bronchoscopy was performed, only 800 cc was raised, but the day following it increased to 1,700 cc, because the al-

## TERMINOLOGY

It is not necessary to define pathologic conditions but I shall give brief explanations of what is meant by the terminology in certain procedures

**Drainage** The emptying of the products of infection directly through the wall of the chest

**Pneumonotomy** An incision or other opening made into infected tissue of the lung in which there is no gross collection of pus

**Bronchostomy** The deliberate opening of the bronchus whether directly or through an abscess cavity, together with the attempted maintenance of a passage from the bronchus through the wall of the chest

**Pneumonolysis** A procedure by which a lung, in part or in whole is directly mobilized or compressed or both whether from without or within the pleural sac, by operation This method is usually applied in upper lobe disease (apicolysis)

**Thoracoplasty** An operation on the thoracic cage intended to reduce the size of the hemithorax and to produce other mechanical changes within the chest

Any other procedures which may be mentioned are made clear by their titles

## CAUSES OF DEATH

In assigning the cause of death, the final operation usually but not invariably, appeared to have had most to do with the fatal termination except in rare instances, death will be ascribed to this operation Thus in the case of a patient who has had several previous operations these are not necessarily referred to but the procedure which seems to have had the determining influence will be mentioned As an example a patient with bronchiectatic and other suppurations of a lower lobe who has been subjected to avulsion of the phrenic nerve and graded thoracoplasty without improvement, dies of recurrent hemorrhages following pneumonotomy with the establishment of a bronchial fistula The cause of death is listed under bronchostomy this being the final operation and the probable cause of the fatal hemorrhages

Before operation every patient was suffering from a suppurative condition of the lung which presented phenomena of systemic toxemia

Of the 105 cases 46 were acute and 59 chronic The designation of chronicity is not an arbitrary one reckoned by weeks or months but the history of each case was examined and the designation applied according to the impression made Twenty-five of the forty-six acute cases were fatal and twenty-two of the fifty-nine chronic cases

A number of patients were referred to me for surgical treatment but operation was not performed Several of these patients died under postural and other treatment and a number died of complications of hemoptysis I shall refer to only operative cases



# NONTUBERCULOUS BRONCHOPULMONARY SUPPURATIVE LESIONS

RESULTS OF TREATMENT BY ARTIFICIAL PNEUMOTHORAX \*

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AND

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BOSTON

Because of the great divergence of opinion in regard to the value of artificial pneumothorax in the treatment of patients with nontuberculous bronchopulmonary infections, and because of the lack of agreement as to how long the treatment should be kept up in order to produce satisfactory results, a discussion of the subject might not be unwelcome at this time

In an endeavor to arrive at some definite idea as to the actual value of this method of treatment in cases of suppurative infections of the lung, one of us (Balboni) has made an intensive search of the world's literature on this subject covering the last twenty-four years. All the references and abstracts of each report are published with this paper.

It has been a difficult matter to determine just what definite results many authors have obtained, and difficult or impossible to tell in what classification certain of their cases belong.

We have added twenty-three of our own cases taken from the Massachusetts General Hospital and the Peter Bent Brigham Hospital, Boston.

In our own series, which cover approximately seven years, there were eighteen cases of abscess of the lung, and five of bronchiectasis. The results were briefly as follows:

Artificial pneumothorax was attempted in eighteen cases of abscess of the lung. Two patients were completely cured and remained so, the treatment being kept up twenty-four and fifteen weeks, respectively. In two cases, there was temporary improvement (one patient died a year later of bronchopneumonia). Partial pneumothorax brought about improvement in all the symptoms in one patient, fifteen months after the suspension of the pneumothorax, the patient died of an embolus. There have been three deaths due to hemorrhage from the lung during treatment. In these three cases, a partial pneumothorax was created, but the lobe from which the bleeding came was adherent either to the wall of the chest or to the diaphragm, and pneumothorax was ineffective.

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\* From the Medical and Surgical Service of the Massachusetts General Hospital

(b) *Bacterial Embolism*—It is more difficult to avoid than air embolism, but an operation in which the pulmonary venous trunks are closed by ligature before the indurated tissue is wounded is not apt to be followed by septic embolism. This method is rarely if ever followed except in lobectomy, which will not be considered here.

It is easily conceivable that cerebral infection is liable to follow cauterization of the lung at the time when the sloughs are cast off. It must not be overlooked, however, that suppurative metastases to the brain may occur even without operation.

*Hemorrhage*—Fatal bleeding is fortunately not often encountered during an operation. It is, however, common during the postoperative period, and may occur months or even years afterward. It is a particularly dangerous accident, because in spite of packing massive hemoptysis is apt to drown the patient.

Although Dr. Graham, in his interesting work on the destruction of pulmonary tissue by actual cautery, depends on the low pressure in the lesser circulation to aid in hemostasis, the danger of hemoptysis has been very real in my own experience.

*Mediastinitis*—Only one of my patients succumbed to this complication. It followed an attempt to ligate a large branch of the pulmonary artery near the hilum through indurated tissue of the lung.

*Diagnostic Puncture*—There were two cases in which death followed diagnostic puncture of an abscess of the lung. Puncture in each instance was made before the patient entered the surgical service, and by the time he was seen by me there was extensive putrid phlegmon throughout the muscle planes of the back. Diagnostic puncture of the lung, except as a preliminary to immediate operation, should never be performed.

*Contralateral Conditions of the Lung*—There were seven cases in which death followed contralateral conditions of the lungs, including pneumonia, edema and abscess. While it is difficult to be certain that abscess was not present in the opposite lung before operation, edema and pneumonia as postoperative complications are well known and not always explainable. Massive collapse has also been reported.

*Preoperative Sepsis*—In sixteen cases death occurred from preoperative sepsis.

*Shock*—In two cases cardiac collapse and death occurred shortly after the operation.

*Acute Nephritis*—Death occurred in one case in which the patient had not been known to be affected before the operation. At the time the thorax was progressing normally. Whether this was a separate disease or had something to do with the operation is impossible to state, since examination was not made.

TABLE 1—*Authors' Series of Cases of Abscess of the Lung*

Case	Duration of Disease	Pneumothorax	Complications	Operation	Result
1	6 months	Partial 10 months	Adhesions	0	Improved at first, died 15 months later of embolus
2	4 months	Partial, 3 months	Sterile fluid, adhesions	Aspiration of fluid	Slight improvement, died a year later from bronchopneumonia
3	2 weeks	Partial 2 weeks	0	0	Reported well one year later
4	2 years	Partial 3 months	Sterile fluid, adhesions	Thoracotomy	Sepsis, died
5	14 months	Partial 4 months	Sterile fluid, adhesions	Phrenic neuromy	Cured
6	2 months	Failed, none	Abscess of the brain	None	Died
7	5 months	Partial 2 weeks	Adhesions, rupture, empyema	Rib resection drainage	Cured by operation
8	16 months	Failed, none	0	0	No change
9	5 months	Partial, 2 weeks	Adhesions	0	No change
10	2 weeks	Failed, none	0	Resection of rib and drainage	Marked improvement, later reported well
11	1 week	Partial, 2 weeks	Adhesions	Drainage of abscess	Improved by operation
12	3 months	Partial, 1 week	Adhesions, rupture, empyema	Rib resection, drainage	Cured by operation
13	3 months	Partial, 5 days	Adhesions, rupture empyema	Rib resection, drainage	Cured by operation
14	1 year	Partial, 6 days	Adhesions, rupture empyema	Rib resection, drainage of pleura and abscess	Improved by operation, still under treatment
15	8 months	Partial 3 months	Adhesions	None	Sudden fatal hemorrhage
16	1 year	Partial 4 hours	Adhesions	Operation and drainage of abscess	Sudden fatal hemorrhage
17	5 weeks	Partial, 2 weeks	Adhesions	None	Sudden fatal hemorrhage
18	4 weeks	Complete, 15 weeks	0	0	Cured

TABLE 2—*Authors' Series of Cases of Bronchiectasis*

Case	Cured	Weeks of Treatment	Improved	No Improvement	Failure to Produce Pneumothorax	Complications		Died
						Sterile Pleural Effusions	Empyema	
1	1	90				1		
2					1			
3					1			
4		52		1			1	1 (Following operation)
5		28	1	Still under treatment		1		
	1		1	1	2	2	1	1

## CHOICE OF PROCEDURE

*Artificial Pneumothorax*—This method finds its principal application in cases of abscess discharging by bronchus and in the earlier stages before the formation of a too rigid wall. I say this in spite of the fact that a few cases have been reported in which the disease had lasted a long time. In one reported by Forlanini, the final cure of a chronic putrid abscess took place after two years of treatment.<sup>1</sup> This isolated case should not, however, be held as an example especially in view of the dangers always present in this form of therapy. Patients with abscess of the lung not accompanied by too great bronchial dilatation may recover without treatment of any kind, this should always be borne in mind, especially when the physician is dealing with patients afflicted with some other serious illness.

*Thoracoplasty*—When thoracoplasty is performed there is a good chance for relief or clinical cure when the disease is of long duration and when fibrocavernous and bronchiectatic changes have occurred in an entire lung, and the opposite lung is healthy. There are two principal causes for the failure of this method (1) interference with the drainage of a cavity by the collapse itself and (2) the failure of the wall of the chest to obliterate the abscess cavities on account of the rigidity of their walls. Cough and expectoration continue or may become aggravated, or the condition may become acute, so that further operative procedures such as drainage will be required.

*Extrapleural Pneumonolysis*—This is a valuable procedure in certain cases of apical disease in which there are few or no pathologic changes in the remainder of the lung. By direct pressure, even the rigid walls of the abscess may sometimes be collapsed.

*Intrapleural Pneumonolysis*—Intrapleural pneumonolysis has seldom been performed deliberately. It has been successful in two of my cases in which it was done only because the employment of any other procedure did not seem possible after the chest had been opened.

*Drainage*—Drainage as an operation of choice in chronic cavitary abscess has proved its efficacy in many instances. It is more likely to succeed when a connection with the bronchial tree is either direct or small, because then expiratory effort tends to approximate the wall of the abscess. It is merely the modification of the usual surgical procedure for evacuating pus from a suppurating area.

*Pneumonotomy*—I have found pneumonotomy of value only in cases of indurated lung usually when there are numerous small abscesses resembling the structure of carbuncle. As the disease

<sup>1</sup> Garre and Quincke, *Munch. med. Wochenschr.*, 1890, 17, 1021.  
Surgery of the Lung, ed. 2, tr. n. New York, N. Y., 1900, p. 102.

TABLE 3—Cases of Abscess of the Lung Taken from the Literature

Author	Case	Duration of Disease	Pneumothorax	Complications	Other Treatment	Operation	Result	Comment
Riva Roel, 1903	1	3 months	Partial	0	0	0	Cured	
Forlanini, 1910	1	6 years	Almost complete, 1½ years	0	0	0	Cured	Well 4 years later
A Schmidt, 1910	3	?	1 partial	0	0	0	Cured	
			1 partial	0	0	0	?	
			1 partial	0	0	0		
			1 partial	0	0	0		
			1 more extensive	0	0	0		
Wellman, 1910	2	?					Not improved	Pneumothorax abandoned After a fit of coughing, expelled 1,200 cc foul sputum, recovery
Volhard, 1912	1	?	Partial				Died	
Lowenhjelm, 1912	1	Months	Partial	Infection of other lung,	0	Withdrawal of air	Died	
			Partial	0	0	0		
			Complete	0	0	0	Not improved	
			Partial	0	0	0	1 cured	
Kling and Mills, 1913	1	Months	Partial	0	0	0	Died	
Foranea, 1913	1	1 year	Cough, 9 months	0	0	0	Cured	
Balboni, 1914	2	6 months	Almost complete, 6 months	0	0	0	Cured	
R C Matson	1	1 year	Partial	Cough worse	0	0	Not improved	Six months later, died
	2	1 week	Complete, 8 months	0	0	0	1 no benefit	
			Partial	0	0	0	Cured	
			Complete	0	0	0	Improved	
Webb and Gilbert, 1914	2	Short time					Cured	Abscess secondary to foreign body, expelled
			Partial	Bad general condition	0	0	Died	
			Partial, 3 months	Indurate		Aspiration of fluid	Cured	Six months after suspension of treatment, reported well
Centani and Arena, 1914	1	3 months						
Reichman, 1915	1	2 months	Complete, 1 month	None	0	0	Cured	
Lauret and Hubert, 1914	3	8 months	Complete	0	0	0	3 cured	
			Complete					
Lindwall, 1915	1	1 year	Partial, 4 months	Syphilis	Mercury	0	Cured	
Epifano, 1916	1	1 year	Complete, 4 months	0	0	0	Cured	
Antonucci, 1916	1	4 months	Partial, 1 months	0	0	0	Cured	
	1	3 months					Worse	
Greer, 1916	1		Complete, 1 month	0	0	0	Cured	Well several months after complete reexpansion
Tewksbury	14	1 to few weeks	8 months, 2 partial	1 empyema, 1 labor	0	Rib resection	2 no improvement, 9 cured, 3 died	Interlobar empyema communicating with bronchus All these patients were treated early
			Complete	0	0	0	Cured	
			Complete	0	0	0	Cured	
Simon and Sweeney, 1918-1919	1	2 years	Almost complete	0, 1 pericarditis	0	0	1 cured, 1 died	
De Verblion and Loiseau, 1918	1	3 weeks	Complete, 3 months	0	0	0	Cured	
Well and Loiseau	2	?	Partial	Extension of disease	0	0	Died	Four months after last injection, reported well
Klinkert, 1918	1	6 months						In these two cases there was extension of the disease and patients died suddenly after last insufflation
Wessler, 1919	2	?						
			Partial, 1 month	Empyema	0	Rib resection	Died	
			2 complete	0	0	0	3 cured	
			2 none	0	0	0	1 died 1 worse	
Brunning, 1919	1	Weeks						
Bergman, 1919	5	?						

The following case shows the hazards always present in pulmonary suppurative lesions

Lina R., aged 21, had a putrid abscess following tonsillectomy. Drainage with permanent bronchial fistula was secured, and the patient was well satisfied with the result, refusing further operation to close the stoma. As a protection she wore a light piece of gauze pinned to her undergarment, except when she caught cold and a mucopurulent discharge appeared.

Four and a half years later, there was a hemorrhage from the stoma. It was checked by packing. During the first stage of an operation to prevent a recurrence of the bleeding, she died of cerebral air embolism.

Before deciding on a major surgical procedure all other methods reasonably promising relief should have been tried and examination by roentgen ray and bronchoscopy should have been made.

After most operations resulting in a chronic or permanent opening in the wall of the chest, a state of seminvalidism follows, even though the patient may be able to work. Accidents, such as a lighting up the disease with an extension of the gangrenous process and hemorrhage are apt to occur.

Much has been written on the question of the propriety of operating in chronic and in acute cases. Miller and Lambert, after an extensive experience, conclude that operation in cases of acute putrid abscess is unsafe, but that the drainage of chronic abscess is justified. No one can say, however, which acute abscess will become chronic, and progressive gangrenous suppuration cannot be permitted to go on without some incisive attempt to check it. Doubtless, operative statistics will suffer if operation is performed for acute abscesses, but if some patients are saved who might otherwise perish, operation is justified.

This discussion would be incomplete without a comparison with lobectomy. I feel that this operation has not had the attention which it deserves, and I am glad to note in the literature that there appears to be a movement in favor of the complete extirpation of a diseased suppurating lobe in suitable cases (Eloesser). The latest encouraging reference to lobectomy which has come to my notice is to be found in the Proceedings of the Staff Meeting of the Mayo Clinic for March 2, 1927 in which S. W. Harrington reports that Sauerbruch is performing the operation in stages. It is probably true that the technique of lobectomy as I have performed it in one or at the most two stages is the most improved. Certainly those of my patients who have had complete recoveries after lobectomy are more nearly normal both as to appearance and as to body symmetry than could be expected after any other procedure for similar pathologic conditions, and as I have stated in my paper<sup>2</sup> the vital capacity as shown by spirometer is high.

<sup>2</sup> Lilienthal, Howard: Vital Capacity and Body Symmetry after Lobectomy. *Ann. Surg.* 1926, 82: 286 (Jan) 1926.

TABLE 4—Cases of Bronchiectasis Taken from the Literature

Author	Cases	Duration of Disease	Pneumothorax	Complications	Other Treatment	Operation	Result	Comment
Riva Rocci Brauer, 1896	2 4	4 years 3 years 10 years 22 years 6 years	Complete, 1 year Partial, 4 months Partial, 4 months Complete, 2½ months None	0 1 exudate 0 Pleural cavity obliterated 0	0 0 0 0 0	Rib resection 0 0 0 0	Cured Slight improvement Improvement Slight improvement None	No subsequent history, bilateral case Improvement during treatment Treatment given up
A Schmidt, 1908	4	Several years	Partial, 3 months 1 none	0 Pleural cavity obliterated 0	0 0 0	0 0 0	None None None	Three unilateral, results negative One bilateral
Oscar Frank v Jagle, 1910	1	Years	Partial, 1 month	0	0	0	Marked improvement	Still under treatment at time of publication
Wellman, 1910	1	Years	Almost complete	0	0	0	Marked improvement	Unilateral case, year later about the same
Luxemborg, 1910	1	1 year	Almost complete, 2½ months	0	0	Plastic operation	Slight improvement	Unilateral case, short duration treatment
Brauns, 1912	3	Years	Complete	0	0	0	2 cured 1 improved	Unilateral Bilateral, still under treatment at time of publication Unilateral
Volhard, 1912	1	Years	Partial	0	0	0	Marked improvement	
Kellar, 1912	4	13 years	One side, then the other	Adhesions	0	0	Died	
Koniger, 1912	2	4 years	Complete, 1 month	0	0	0	No effect	Bilateral
Hochhaus, 1912	4	1½ years 4 years	Complete, 1 month	0	0	0	Marked improvement	Bilateral, able to do full time work 2½ years later
Pekunovics, 1913	1	Years	Partial	0	0	0	Improvement	Bilateral
Penzoldt, 1913	1	Years	Partial	0	0	0	Improvement	Later results not known
G Singer, 1913	3	Years	2 none, 1 partial, week	Pleural infection	0	0	None Slight improvement	No later results reported
Zink, 1913	1	3 years	Partial, 10 months	0	0	0	Improvement	
Angelini, 1913	1	3½ years	Partial	0	0	0	Improvement	
Riesdicker and Vogt, 1913	4	1 year 2 years 3 years 4 years 1 year	Partial Partial Partial None None	Rupture of cavity	0	0	Died	
R C Matson, 1914	2	Years	1 partial 1 year	Adhesions	0	0	Improvement	Bilateral case, slight improvement with pneumothorax, abscess cavity 1 year later
Balboni 1914	2	Years	1 complete	0	0	Rib resection draining cavity	Marked improvement	One year after treatment died, pneumonia

# ABSCESS OF THE LUNG RELIEVED BY BRONCHOSCOPY

REPORT OF CASES

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NEW YORK

I have entitled my paper "Abscess of the Lung Relieved by Bronchoscopy" because I, like others, have been disappointed in the results of this treatment. Some patients whom I thought were cured were not. One patient who was cured of cough and who was free from symptoms later developed abscess of the brain and died. After a free interval of two years, another patient had a hemorrhage and an operation was necessary.

As to etiology, twenty of 103 cases that I have seen in the last two years and a half had no clear cause. It is sometimes difficult to find the cause; the patients say that they had had pneumonia or had been in poor health for a year or two and then began to cough up sputum. I have listed the causes in the table.

*Conditions Which Preceded Abscess of the Lung*

No conditions known	20
Pleurisy	6
Pneumonia	12
Tonsillectomy	27
Operation for appendicitis	2
Operation for hernia	2
Submersion	3
Operation for scirrhus	1
Exposure to gas during war	1
Colds, exposure and chill	3
Congestion of the lungs	1
Bronchitis	5
Influenza	1
Indefinite operations	5
Foreign bodies	9

In this table the incidence of abscess of the lung after tonsillectomy does not approach that reported by Dr. C. C. ...

As a rule cases in which foreign bodies were retained are considered cases of abscess of the lung for development of abscess. The following cases were those in which the foreign body was retained for a long time: cases in which the foreign body was retained for four, seven, nine and twenty-three years. In one case wood was present for four years, in another case for seven years, in a case in which a piece of glass was



Fluid will develop at some time or other during treatment by pneumothorax whether the case is tuberculous or nontuberculous. There may be a small amount of fluid that can be perceived only by the fluoroscope.

#### SUMMARY

It seems fair to say that the patient with abscess who stands the best chance of being cured by artificial pneumothorax is the one in whom the following conditions are fulfilled, (1) the abscess is situated centrally, (2) it communicates with a bronchus, (3) the treatment is established within three or four months from the onset of the disease, (4) a complete or almost complete collapse can be obtained, (5) the treatment can be kept up between three and four months, and (6) artificial pneumothorax is not an indifferent procedure.

#### REPORT OF CASES

CASE 1—M. P., a fairly well developed Italian girl, aged 21, had had a cough of six months' duration which developed following a cold. She raised a large quantity of foul sputum in which there was blood at times, and she had had night sweats and chills and had felt weak.

The sputum was negative for tubercle bacilli. Roentgen-ray examination showed an area of dulness around the second and fourth ribs on the right side which extended across the chest from the roots of the lung to the axillary border. The dulness was of an even density except at the borders, where there was some mottling. The apices were clear.

The pathologic process at the base of the upper lobe of the right lung was diagnosed abscess of the lung.

Artificial pneumothorax was kept up for ten months, when it was abandoned, as the lung was only partially collapsed, the upper lobe being adherent. There was improvement at first, but the patient died fifteen months later from an embolus.

CASE 2—F. E. O., a white girl, American, aged 19, single, an employee in a shoe factory, was admitted to the hospital on March 16, 1920. Four months before admission a tonsillectomy has been performed. The patient felt sick and had fever and weakness afterward. About one month later, a cough developed with considerable foul sputum, occasionally blood-streaked. During the second month after the operation, the condition improved, then she had a chill and a constant increase of symptoms. Three cups of sputum were expectorated daily. During the cough, pain was felt on the right side.

Physical examination showed that a bronchiectatic condition was probably involving the right lung. Roentgen-ray examination was made on March 18. The appearance of an extensive pneumonic process in the lower part of the right side of the chest suggested evidence of bronchiectasis and retraction of the part of the lung involved. Definite evidence of a cavity was not seen. The heart was considerably displaced to the right.

Artificial pneumothorax was performed on April 15, 575 cc of air being injected into the right pleural cavity. Roentgen-ray examination on the same day showed that the pneumothorax lay low on the right side. A sharp outline of a shadow below resembled the liver, and above it resembled the diaphragm.

or more bronchoscopies were performed on these thirty-one patients. Of the thirty-one were cured as they did not have a cough sputum or fever but later, two developed some other disease and died. Of the other fifteen were improved, nine were not traced and are considered lost and four are under treatment.

A certain number of the cases were operative. Of these patients on whom operation was performed, two died and three were cured. The results in the other cases are unknown.

The patients that seemed to respond best to bronchoscopy were those on whom this operation was performed following tonsillectomy. The

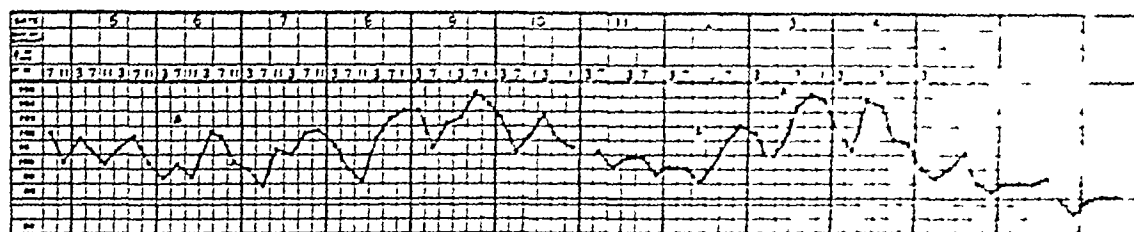


Fig 2—Temperature curve after bronchoscopy. This illustrates the case as does figure 1. A indicates a roentgen-ray examination. B, performance of bronchoscopy.

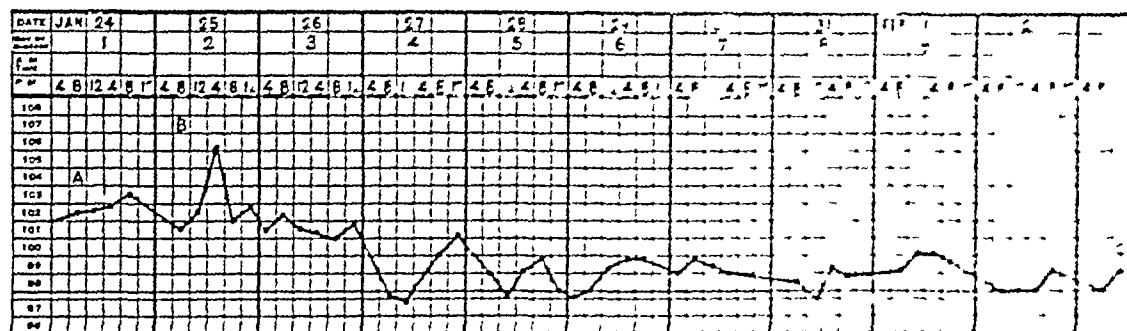


Fig 3—Temperature curve after one bronchoscopy. The abscess was of one month's duration. A, diagnosis in hospital. B, performance of bronchoscopy.

is striking, and I suppose that others have found it so. Of the twenty-seven patients on whom bronchoscopy was performed following tonsillectomy, fifteen were cured. Of these fifteen had dramatic cures—that is, following the operation the temperature and the amount of sputum fell, the patient went on to complete and uninterrupted recovery. Of the ten cured by bronchoscopy, three died, two were not traced, and these recovered and one died. The results in the other

One death may be attributed to the operation. The operation was performed on this patient on Jan 26, 1931.

A roentgen-ray examination on January 15 showed the outer margin of the dull area at the base of the right lung much more sharply defined and the total area of dullness diminished.

On January 17, the lower lobe of the right lung was fairly well collapsed. The area of pneumothorax was in the costophrenic angle. The upper part of the lung was completely expanded.

On January 24, 650 cc of air was injected with the pressure at +5 at the end of the injection. The patient coughed and raised sputum three times during the injection. She continued to do well. A roentgen-ray examination on January 25 showed a partial collapse of the base of the lung.

The treatment was discontinued because of lack of cooperation by the patient. In April 1923, a report by letter stated that the patient was well and working.

CASE 4—C T C, a man, aged 33, had a tonsillectomy performed on Aug 28, 1921, ten days later, he began to cough and raise foul yellow sputum, about one cup a day. In September, 1922, he had his first hemoptysis. In March, 1923, he had several slight hemorrhages and he had a severe one on May 22, 1923. He was admitted to the hospital on May 22, 1923.

His family history and past history were not unusual.

Physical examination showed a well developed and well nourished man, who raised a great deal of blood-tinged, yellow sputum, not particularly foul. There was dullness over the left apex, and many moist rales were heard throughout the left lung. Tactile fremitus and spoken and whispered voice were increased over the left side of the chest.

The diagnosis was abscess of the upper lobe of the left lung.

On May 28, 1923, following a hemorrhage of 700 cc of blood, artificial pneumothorax was performed, and 900 cc of air was injected into the left side of the chest. On May 30, 250 cc of air was injected, on June 5, 400 cc, on June 14, 350 cc, on June 19, 400 cc and on June 22, 350 cc. The patient raised blood-streaked sputum at this time.

On June 26, 250 cc of air was injected into the left side of the chest. On June 19, a roentgen-ray report showed an increase in the size of the pneumothorax. There appeared to be a clearing at the apex of the left lung and a collection of fluid at the base, the apex was not collapsed, and was adherent both posteriorly and laterally.

On June 30, 375 cc of air was put into the left pleural cavity, on July 7, 250 cc, on July 12, 150 cc, on July 13, a roentgenogram showed the upper lobe still adherent, the lower lobe collapsed, and more fluid in the pleural cavity. On July 14, 200 cc of straw-colored fluid was removed. Bacteria or tubercles were not found. On July 29, 500 cc of air was injected.

On August 3, the patient was discharged with his general condition much improved. The cough and sputum were less, the sputum was not foul, and the tests for tubercle bacilli were negative.

On August 9, the patient reentered the hospital, and 400 cc of air was put into the left pleural cavity. On the same date a roentgen-ray examination showed some reexpansion of the lung with several fluid levels at the base. The patient was discharged. He reported at the outdoor department in October and showed some improvement. He was advised to have an operation with resection of the rib and collapse of the lung.

On Jan 18, 1924, he reentered the hospital with definite dullness and absence of breath sounds, tactile fremitus and vocal fremitus over the greater part of the whole left side of the chest. Dullness was most marked at the apex. The patient asked us to perform an operation.

bronchoscopy he sat up on the table, said how well he felt and then fell back in a convulsion. He died in twenty-four hours, so that bronchoscopy is not without danger. At autopsy an embolus was found in the brain. I suppose that this death following bronchoscopy was immediately due to it, but that is only one death in many hundreds of bronchoscopies.

I wish to illustrate two points: (1) that the cases particularly favorable for bronchoscopy are those following tonsillectomy, and (2) that



Fig. 6—Injection of iodized oil (40 per cent solution) into an abscess of the lung.

the earlier the patients are treated the better. The following cases will demonstrate these points.

This first case was of eighteen days' duration. After a tonsillectomy the patient developed an abscess in the upper lobe of the right lung, which was formed eleven days later. This was Dr. H. H. S. Case. After bronchoscopy was performed the abscess cavity collapsed, the pulmonary tissue collapsed. I suppose that this was the first

angle The lung was somewhat expanded since the last roentgenogram was taken There was probably air in the apex, in the costophrenic angle and in the narrow region along the axillary border

On July 15, 600 cc of air was easily injected, and the sputum was seen to be decreasing Roentgen-ray examination showed the area of the lung to be smaller than before, but not completely collapsed

On July 23, 200 cc of air was injected The needle became plugged On August 3, 750 cc of air was injected Roentgen-ray examination on August 4 showed that the pneumothorax extended from the apex of the right lung to the base along the axillary margin, it was about 1 inch wide (2.5 cm) in its narrowest portion The dulness in the costophrenic angle suggested a small amount of fluid

The patient was discharged to a convalescent home to build up her general health In December, 1926, a letter stated that she did not have a cough and did not raise sputum

CASE 6—F. E. C., a man, aged 66, entered the hospital on April 13, 1923, he had had symptoms of duodenal ulcer for three years On April 23, a gastro-jejunostomy was performed On May 9, roentgen-ray examination of the chest showed signs suggestive of pneumonia at the base of the right lung

On June 11, the patient had a foul breath, but the sputum was not particularly foul Many rales were heard throughout the back Artificial pneumothorax was performed 200 cc of air being injected On June 12, 200 cc of nitrogen was injected, on June 13, 350 cc, on June 15, 400 cc and on June 22, 400 cc On June 25, roentgen-ray examination failed to show any evidence of pneumothorax On August 1, the patient's condition was unaltered, the sputum was still foul On August 9, the pulmonary signs were clearing up somewhat, and the appetite was excellent The patient was sitting up in a chair The temperature rose to 102 F On August 10, he became unconscious and died

Autopsy showed abscess of the lung pleurisy on the right side, healed duodenal ulcer and a healed gastro-jejunostomy passage

At autopsy, the right lung weighed 680 Gm It was mottled, and the upper lobe showed depression On section, an abscess that measured 3 cm in diameter was seen below these depressions It contained pus which had a foul odor and was surrounded by a gray, necrotic zone The lung tissue peripheral to this zone was congested Two smaller abscesses were seen in the middle lobe They were less extensive, and the reaction about them was less marked than that in the upper lobe The left lung weighed 800 Gm and was normal The pleura was attached to the right lung

CASE 7—E. H., a woman, aged 18, white, Finnish, single, without an occupation, was admitted to the hospital on Feb 14, 1923 Five months before admission her adenoids and tonsils had been removed A few days later, she had a cough and pain in the right side of the chest At that time a roentgen-ray examination showed a dense area in the third to fourth interspace near the periphery on the right side A month later, the lung had a more normal appearance with cavitation in a dense area In another month, roentgen-ray examination showed almost complete disappearance of the condition The third month later (i. e., after operation), the patient began to cough again, and had fever and night sweats Four months later (in January), she had a hemorrhage and lost 1 pint of blood The cough and sputum increased and the sputum again contained blood and pus

The physical examination showed a pathologic process in the right side of the chest On February 19, 650 cc of air was injected into the right side Roentgen-



Fig 8—Abscess of the lung one year after tonsillectomy The tip of the injection tube is seen in the cavity

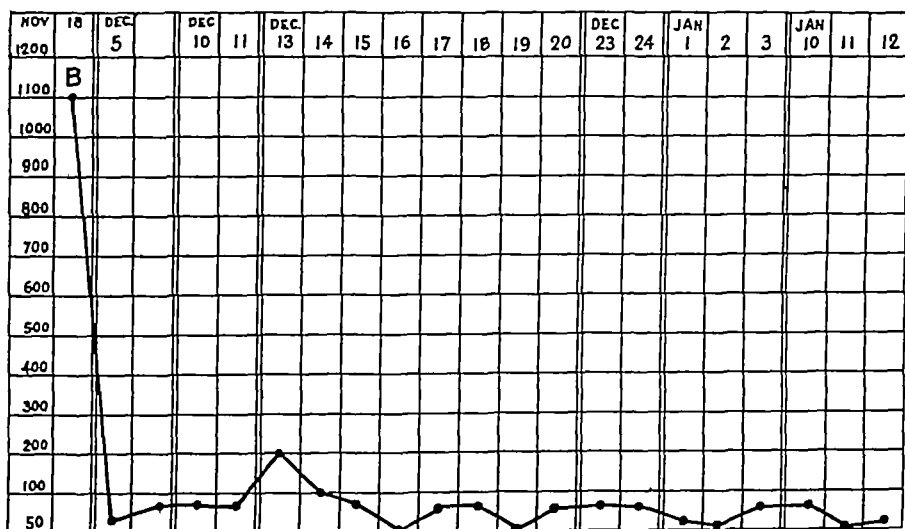
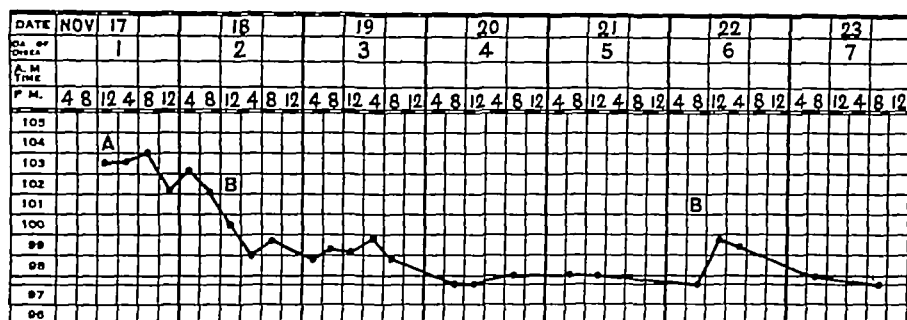


Fig 9—Effect of bronchoscopy on the temperature curve and amount of sputum This illustrates the same case as does figure 8 A indicates the time of admission, B, performance of bronchoscopy

There was frequent hemoptysis. The sputum was mucopurulent and foul. He had lost 22 pounds (10 Kg) during the three months in bed. Later he was up and about, but did not work, and he regained his normal weight.

Examination of the chest showed a diffuse pathologic condition involving both the upper and the lower lobe of the right lung. A bronchiectatic or bronchopneumonic process shown in the right lung by the roentgen ray was perhaps of the nature of an acute abscess formation. A distinct cavity formation was not seen.

On July 11, 500 cc of air was injected into the right side. Roentgen-ray examination did not show any evidence of air in the pleural cavity. Air was seen in the subcutaneous tissues. Treatment by pneumothorax was abandoned, as there was not a free pleural cavity. Antisyphilitic treatment did not cause any change in the picture of the lung.

Operation and drainage were suggested.

CASE 9—E. H., a woman, aged 27, white, Swedish, married, a housewife, was admitted to the hospital on March 22, 1923. Nineteen weeks before admission tonsillectomy was performed under ether anesthesia. Two weeks later, pain developed in the right shoulder followed first by a dry cough, then by abundant foul, brownish sputum, some hemoptysis, night sweats and considerable loss of weight.

Examination of the chest showed that the expansion was diminished, tactile and vocal fremitus, dullness, bronchial breathing and rales were present over the right apex down to the spine of the scapula behind and to the fourth rib in the front. Roentgen-ray examination showed definite evidence of a pathologic process in the upper lobe of the right lung. In the absence of demonstration of a cavity, there was no positive evidence that it was an abscess.

Artificial pneumothorax was instituted on March 26, 500 cc of air being injected into the right side. Roentgen-ray examination on March 27 gave evidence of considerable gas in the pleural space, but apparently the gas had not separated the lung from the wall of the chest in the axillary margin.

On March 31, 500 cc of air was easily injected. Roentgen-ray examination on April 2 showed an increase of air in the chest, but the lung was not separated from the axillary margin. On April 3, 500 cc of air was injected. There was still considerable cough and sputum. On April 11, 700 cc of air was injected. The symptoms did not improve. Roentgen-ray examination on April 12 showed that the lung was about half the normal size, with dense narrow bands (adhesions) across from the axillary margin to the wall of the chest.

Artificial pneumothorax was ineffectual. The condition remained about the same. Operation was not indicated.

CASE 10—J. C., a white man, aged 21, a Russian, single, a junk dealer, was admitted to the hospital on Aug. 3, 1923. He had been in an automobile accident two weeks before admission. His nose had been broken and set under ether anesthesia three days later. About one week later, he suddenly began to cough and expectorate a dark, thick, foul sputum, which had persisted, about one glassful being raised every day. The cough was worse when he lay on either side. He had had pain over the lower left side of the chest for about one week. Fever and sweats developed.

Physical examination of the chest revealed an abscess of the lung, probably situated midway down the left axilla, more anteriorly than posteriorly, although it could not be definitely localized. The patient was ill. There were 27,000 white blood cells. A roentgenogram on August 4 revealed an area of diminished density, which was probably an abscess formation with a large cavity containing fluid.

patient was coughing up considerable pus, and on bronchoscopy the pus was traced to the upper lobe of the right lung, as indicated in figure 4. After bronchoscopy, the patient made an uninterrupted recovery. It is now over two years since bronchoscopy was performed. He was operated on for suppuration in the paranasal sinuses, and tonsillectomy had also been performed. It has been necessary to direct the treatment to the antrums to allow him to recover his health. The course of the temperature is shown in figure 5, he did not have much fever, 100 F being the highest point. Bronchoscopy was performed when the temperature reached that point. The sputum line was running from

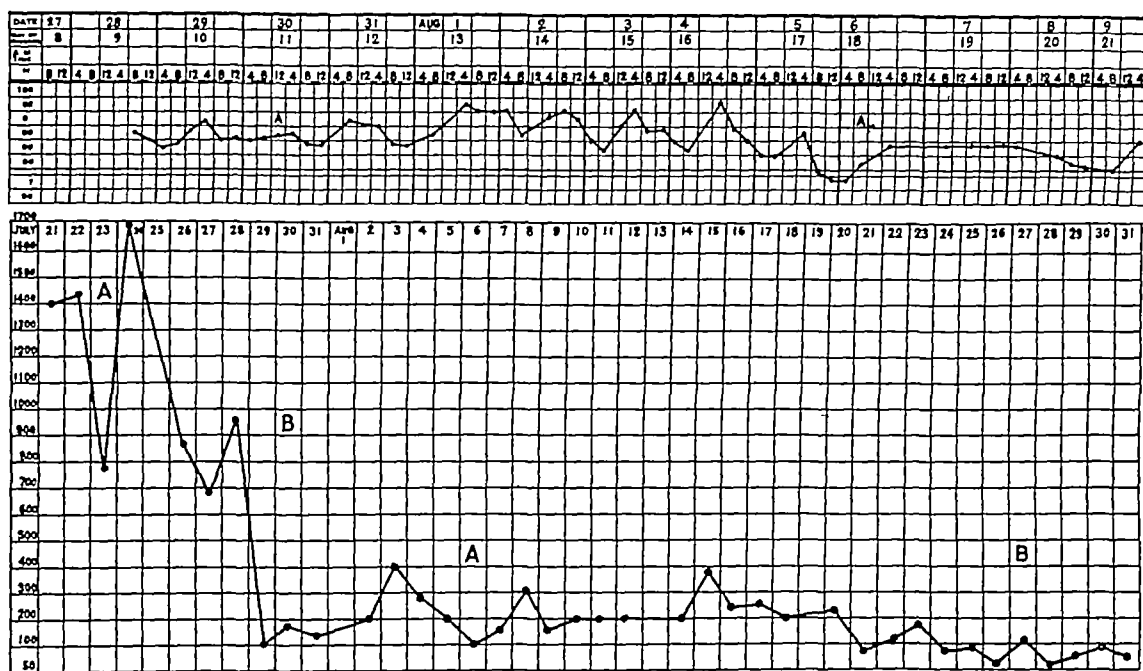


Fig 11—Sputum curve and temperature curve of patient shown in figure 10, A indicates performance of bronchoscopy, B, roentgen-ray examination

300 to 500 cc when the bronchoscopy was performed, the two bronchoscopies were all that was required to bring the sputum down to about 50, and he finally did not raise any sputum.

This abscess was of the same character as the other—a large single lobe abscess cavity located where it could be reached without much difficulty. Figure 6 shows the present situation in the boy's lung. This also illustrates the advantage of using iodized oil 40 per cent with fluoroscopy. It has always appeared reckless to me to pour into the lungs drugs of which one is not sure, moreover, too much of the iodized oil spoils the roentgenogram. The right amount can be exactly placed with the fluoroscope.



examination on April 4 showed practically the same picture as at the last observation, except that the density about the abscess cavity appeared slightly less. Pneumothorax seemed to have done little good. Roentgen-ray examination showed the possible danger of further performance of pneumothorax.

An exploratory thoracotomy was performed by Dr. Whittemore on April 9. A resection of the fourth and fifth ribs was made on the anterior axillary line. The lung was partially collapsed, but was held with a network of adhesions. Explorations showed an indurated area of the lung some distance posterior to the site of approach. The lower lobe was sutured in place in the wall of the chest, and a gauze wick was placed in the indurated area. On April 16, a resection of the seventh rib was performed at the posterior angle, the first stage wound was removed. A deep lying abscess of the lung, probably situated in the middle lobe near the hilum, was opened by finger dissection. A small amount of foul-smelling detritus was evacuated, and a rubber tube was inserted for drainage.

On May 4, distinct improvement was noted. The cough was less and the sputum was of a more glary and frothy character. Roentgen-ray examination on May 9 showed an area of dulness throughout the lower half of the right side of the chest, more dense at the base and along the axillary margin, where it obliterated the outline of the diaphragm and the shadow of the ribs. Its upper border corresponded with the lower border of the lung and fluid. The heart and left lung were normal.

On May 25, the patient was discharged to the outpatient department.

A second operation was performed in 1926. In March, 1927, he still coughed and raised purulent sputum and had a discharging sinus.

CASE 12—E. B. M., aged 29, entered the hospital on Feb. 25, 1924. Two months before, he had entered the hospital on account of pain and cough accompanied by the raising of a small amount of foul sputum each day. The cough was the result of tonsillectomy performed twelve days previous to entrance.

Examination showed rales in the second left interspace anteriorly. The temperature varied from 100 to 101 F. The foul sputum contained many cocci, but tubercle bacilli were not found.

Roentgen-ray examination showed a definite cavity with a fluid level at the second interspace. Artificial pneumothorax had been performed twenty-three and twenty-one days before admission. Roentgen-ray examination showed the lung almost completely collapsed after the second pneumothorax. Three days before entrance, 600 cc. of air was aspirated from the left pleural cavity. Two days before, pus was aspirated from the left pleural cavity. Drainage was performed and 1,200 cc. of pus was removed. The treatment then consisted of irrigation with a surgical solution of chlorinated soda. On March 16, the drainage tube was removed on account of pain. On March 21, resection of the rib was performed. On May 8, the drainage tubes were removed. On May 10, the patient was up in a wheel chair and walking about. On May 17, irrigation with a surgical solution of chlorinated soda was begun again and kept up until July 9, when the tubes were removed. The patient was discharged from the hospital on July 20.

On March 14, 1927, the patient's physician reported that she was completely well and did not have a cough or raise sputum.

CASE 13—A. P., an Italian girl, aged 17, was admitted to the hospital on March 29, 1924. Tonsillectomy had been performed under ether anesthesia sixteen days previously. Eleven days previously, she felt a pain in the chest. Six days later, fever and a slight cough developed accompanied by increased pain.

the outlook of the case may be from the point of roentgen-ray appearance, I think that bronchoscopy in every case should be performed in the hope that improvement may be effected

The next case was that of a man who had had an abscess for a year following a tonsillectomy. He had been in a hospital all that time. On examination, an abscess cavity was found close to the hilum, with dense fibrous tissue about it. This condition was different from that in the other cases which cleared up after one or two bronchoscopies had been performed. After the patient began to improve, bronchos-



Fig 13—Injection of iodized oil. This illustrates the same case as does figure 12

copies were performed during four months before he was finally in a condition to be discharged from the hospital. After the first bronchoscopy, the clinical improvement was remarkable. The temperature chart in figure 9 shows the temperature on admission and at the time when bronchoscopies were performed. Before the bronchoscopy there were 1,100 cc of sputum, and after two or three days the amount decreased and continued to be about 25 cc a day while the patient was in the hospital. That was three years ago, and now he is working on the traffic force and is apparently in the best of health. On account of the dense tissue, a long course of treatment was necessary. I

CASE 15—M L M, a man, aged 52, white, American, married, a milliner, was admitted to the hospital on June 2, 1923. Eight months before admission he began to have bronchitis with an unproductive cough. Three or four weeks later, he had high fever and expectorated a large amount of foul sputum, at times tinged with blood. Three months later, he went to Asheville, N. C., and four unsuccessful attempts were made by Dr. Ringer to produce artificial pneumothorax. He returned to Boston ten days before admission to the hospital.

Examination of the left side of the chest from the second to the fourth ribs showed an anterior area of bronchial breathing, with dullness and a few rales. There was little dullness over the corresponding posterior area. The rest of the lungs was normal. Roentgen-ray examination showed dullness of fairly even density on the left side from the apex to the angle of the scapula, with the exception of a bright spot in the first interspace with a suggestion of fluid level in it.

Artificial pneumothorax was performed. On May 19, 850 cc. of air was injected into the left axillary line near the fifth space. Roentgen-ray examination on May 21 showed partial collapse of the lower lobe and a considerable amount of air in the soft tissues of the wall of the chest. On May 22, 700 cc. of air was injected in the midaxillary line near the seventh space. The patient did not cough, and there was a slight sense of pressure. Roentgen-ray examination on May 24 showed marked increase in the area of the pneumothorax, which now occupied half of the lower part of the chest. The upper lobe of the left lung adhered broadly in the axilla. The pathologic area was about the same size.

Further compression with air seemed unwise. On May 27, exacerbation of temperature, cough and discomfort in the left side of the chest occurred. The patient was discharged on June 2, to be treated outside the hospital by Dr. Balboni. Pneumothorax was kept up for two months. The patient had a sudden fatal hemorrhage.

CASE 16—M B T, a white man, aged 27, was admitted to the hospital on Feb. 26, 1926.

In October, 1925, following bronchial pneumonia, a cough productive of foul expectoration developed. Occasionally, the patient raised a large amount of blood. Tubercle bacilli were not found in the sputum. Roentgen-ray examination showed a process suggestive of abscess at the root of the left lung.

On February, 1926, the patient's condition had not improved, but rather had lost ground, in that he was running a higher temperature at night and raising more sputum each day. Roentgen-ray examination at this time showed a definite abscess with a fluid level in the periphery of the right lung in the area between the third and fourth ribs in the axillary line. Examination of the sputum showed many streptococci, pneumococci, large and small bacilli and large spirochetes but no tubercle bacilli.

On March 1, resection of the third rib was performed under local anesthesia. The lung and pleura were adherent. The abscess was opened and drained. The patient made a fairly good convalescence following this operation, except that he continued to raise considerable amounts of sputum, drained large amounts from the abscess and had several small hemorrhages from the abscess, which were controlled with packing.

On October 6, the patient continued to raise some sputum, but had gained 10 or 15 pounds (4.4 or 6.8 Kg.) in weight and looked better than before the operation. Roentgen-ray examination showed a definite area in the region of the old abscess, but no fluid level. A month previous to this, the patient had been away and had allowed the drainage tube to come out, the sinus was completely healed.

cavity opened wide and the patient was able to empty it. In a few days, the amount of sputum fell to 100 cc. a day, there was a little recurrence and bronchoscopy was performed again, then the amount of sputum diminished and finally disappeared. The temperature curve was not as favorable as the sputum curve, it was discouraging. After the first bronchoscopy, the temperature was about 100 F. The patient was in poor condition when treatment was begun, and it required considerable courage to perform bronchoscopy again, but after the second time, he began to improve, and finally made a good recovery. There is still a good deal of scar tissue, but clinically, the patient is well and able to work and earn his living.

The next case was of a different type (fig. 12). The patient had had pneumonia three years previously, and after that was not well for two and a half years. Six months before admission to the hospital, he began to cough and perspire at night and felt miserable. The condition was discovered in the lower lobe of the left lung. The patient was a well nourished, obese man, with a good color and appeared to be in excellent health, yet he coughed all night and raised an ounce or so of sputum during the day. An attempt was made to bring out the lesion with iodized oil 40 per cent by injecting it through the trachea, but this resulted only in scattering it through the lung without any detail. The bronchoscope was passed under the fluoroscope, and by injection the character of the lesion could be demonstrated. I should say that the lesion appeared to be a sort of carbuncle of the lung—a mass of scar tissue with fistulous tracts. Bronchoscopy was performed for a year or so and finally a cure was effected.

It is sometimes asked whether it is not dangerous to perform bronchoscopy on sick persons who have been coughing, who are in poor condition, and who have a good deal of fever. The surgical chart of one of the patients who had an abscess following an appendectomy is shown in figure 14. Death resulted. The time of bronchoscopy is indicated on the chart. The next day, twenty-four hours later, there was a fall in the pulse rate, respiration and temperature. Shock did not result from the procedure, even though the patient was exceedingly sick at the time and could not lie down. So it can be said that shock does not follow bronchoscopy.

On February 16, he reentered the hospital, and on February 17, his appendix was removed under ether anesthesia. The pathologic report was fibrous appendix. The wound became infected and was irrigated with surgical solution of chlorinated soda. The patient had a slight septic temperature. Early in March, he began to cough and to raise sputum. Roentgen-ray examination showed a definite abscess of the lung with the fluid level in the left lobe.

On March 21, artificial pneumothorax was performed, and 700 cc of air was injected. On March 24, 400 cc was injected, on March 31, 400 cc and on April 4, 500 cc.

On March 17, he raised 150 cc of sputum, on March 19, 75 cc, on March 20, 50 cc, on March 21, 100 cc and on March 22, 20 cc. Tubercle bacilli were not found.

On April 3, roentgen-ray examination showed the lung well collapsed. The patient was discharged on April 19. Artificial pneumothorax was kept up for three months after the patient's discharge, and then the lung was allowed to expand. On March 15, 1927, the patient was well and free from cough or symptoms, the lung was fully expanded.

CASE 19—L. N., a school boy, aged 16, white, Jewish, was admitted to the hospital on Jan. 2, 1923.

Eight months before, his tonsils and adenoids were removed and also "bone from the left side of the nose." Since then he had had a dry cough for three months, then it increased, and he expectorated foul, green sputum. Lying on his back or on the left side aggravated the cough. He did not have fever, slept poorly, and had lost 5 pounds (2.3 Kg) during the last four months.

Examination of the chest revealed that it was resonant throughout except for diminution in the apex and at the base of the left lung. Rales were not heard. Breath and voice sounds were transmitted normally. The fingers were slightly but definitely clubbed. The sputum did not show any tubercle bacilli.

On January 5, a roentgen-ray examination showed a rounded area of increased density with poorly defined borders and a bright spot in its center in the left side of the chest just above the shadow of the diaphragm and adjacent to the shadow of the heart. The area appeared larger with the patient's back to the screen. The left side of the diaphragm was seen faintly. Both apices were clear, and the right side of the diaphragm was regular. The diagnosis was bronchiectatic abscess.

Artificial pneumothorax was performed on January 9, and 800 cc of air was injected into the left side after three attempts. The patient's condition improved, the cough decreasing. Roentgen-ray examination on January 11 showed a small amount of gas in the lower part of the left side of the chest.

On January 12, 850 cc of air was injected, and on January 15 roentgen-ray examination showed that the lung was not completely collapsed.

On January 16, 900 cc of air was injected, and on January 17, roentgen-ray examination showed the entire left lung fairly well collapsed. The involved area at the base was distinctly smaller. On January 19, 900 cc of air was injected. The patient did not feel any discomfort, the sputum was less foul. Roentgen-ray examination on January 20 showed practically complete collapse of the lung. On January 25 and 27, air was injected. The patient's condition was much improved, and he was discharged to the outpatient department for further treatment.

Artificial pneumothorax was kept up until January, 1925. In March, 1925, the lung was fully expanded, the patient was well, and did not cough or raise sputum. On April 28, 1927, he was free from symptoms and was in good health.

Improvement did not occur in two cases, and in three, a satisfactory pneumothorax could not be produced. Empyema complicated the situation in five cases during the treatment. Operation was performed in all cases. Three patients were entirely cured by drainage, one is still under treatment, and one died. It seems questionable whether or not this is an ideal treatment in cases of abscess of the lung.

In the five cases of bronchiectasis, one patient was cured after eighty weeks and one is improved, but is still under treatment after twenty-eight weeks. In one case in which the condition was bilateral, pneumothorax was maintained on one side only. After fifty-two weeks, considerable improvement resulted, then an empyema developed, and death resulted several days after operation. In the other two cases, a satisfactory pneumothorax could not be produced.

In summarizing our own experience in cases of bronchiectasis, it seems fair to say that artificial pneumothorax offers only a small chance of cure, and in the successful cases it must be kept up for a long time. Nevertheless, it seems fair to attempt a pneumothorax in cases of bronchiectasis, as it will not contraindicate surgical intervention later if the pneumothorax should not be feasible or should not produce lasting benefit.

Cases from the literature will be reported in detailed tables. A short summary of the cases of abscess of the lung follows.

Of 129 cases collected, 68 patients (52 per cent) have been reported as cured, and 18 (14 per cent) have died. Empyema developed in 11 cases, and 6 of the patients were cured by operation. There was no improvement in 12 cases.

In the cases in which a cure was reported a complete or almost complete collapse was obtained, and in some of the failures the pleural cavity could not be entered or only a partial collapse was obtained. In the majority of these cases, the abscess was situated near the root of the lung and always communicated with a bronchus. In most of the cases, the disease had existed from one to four months when treatment was begun. The duration of treatment varied, ranging from a week in one case to one and a half years in another. It has been difficult to arrive at any definite conclusions as to how long artificial pneumothorax should be maintained. Many reporters fail to record the duration of the treatment, and those who do report it vary considerably in their accounts, one, three, four and five months were the most frequent periods, probably from three to four months is about the average.

This high percentage of reported cures is extraordinary to us in view of our own experience with this method of treatment. If we add our own 18 cases to the 127 in the literature, the percentage of cases in which cure was reported is slightly lower as out of 145 cases, cure was obtained in 68, or 48 per cent.

decreased. He would not consent to cutting the phrenic nerve. Treatment by pneumothorax was given up after four attempts. The pleural cavity was obliterated.

CASE 21—M. D. N. was admitted to the hospital on Aug. 23, 1923. In October, 1922, he had a severe cold in the chest accompanied by fever and cough. On December 19, the patient had another heavy cold in the chest which lasted up to the time of admission. He had considerable cough and raised sputum. There was a small amount of sputum at first, but this gradually increased until he raised a cupful a day. He had been unable to work since March. For two months, he had had a dull pain in the left side of the lower part of the abdomen.

Examination revealed that the heart was pulled to the right side. A few râles were heard in the upper part of the chest. Voice fremitus was increased slightly. On August 29, roentgen-ray examination showed a dull area of mottled character at the base of the right lung, it extended outward from the root of the lung and occupied the greater part of the right side of the lower part of the chest. Artificial pneumothorax was given. On September 20, roentgen-ray examination showed the right lung completely collapsed. On September 26, the patient was discharged from the hospital.

On Feb. 2, 1925, the patient reentered the hospital. Roentgen-ray examination showed an area of homogeneous dulness, entirely obscuring two thirds of the right lung, with a sharply defined upper border at the level of the third rib. The heart was displaced to the left. The appearance suggested hydropneumothorax of the right lung. Fluid was withdrawn again and replaced with air.

On February 5, roentgen-ray examination showed that the right side of the chest was filled with air. A small amount of fluid was seen at the base. On February 17, the patient was discharged.

On March 13, the patient had bronchiectasis. Pneumothorax was repeated, and the patient was discharged on March 16. On June 1, he reentered the hospital. Roentgen-ray examination showed a shadow corresponding to fluid in the right side of the chest and indicating hydropneumothorax. Fluid was withdrawn again and replaced with air. On June 3, 200 cc of a greenish, cloudy fluid was aspirated, the vital capacity was 2,000 cc. On June 9, fluid was aspirated again, the vital capacity was 1,900 cc. The patient was feeling worse and coughed more. On June 13 and 21, the chest was aspirated. On July 1, the patient had a rise in temperature in the evening. On July 3, roentgen-ray examination showed complete collapse of the right lung. The chest was about one third full of fluid. The patient was discharged on July 15. Pneumothorax was continued for seventeen weeks.

On September 28, the patient reentered the hospital. Fluid was again demonstrated in the right side of the chest. Hydropneumothorax was performed. The patient was raising about 28 ounces (828 cc) of foul greenish fluid during twenty-four hours. Three hundred cubic centimeters of thick, greenish fluid was aspirated from the chest. In October, 500 cc was removed from the chest and on October 11, the patient was discharged. On November 10, he returned to the hospital. His condition was unimproved, and he was raising about six cupfuls of sputum each twenty-four hours. On November 19, he was discharged, but he returned to the hospital on November 27, and was discharged on December 9.

On Jan. 9, 1926, he returned to the hospital. He was still raising a large amount of sputum, and his condition was no better. On January 21, an operation was performed under local anesthesia for resection of the eighth rib. The

A brief summary of the cases of bronchiectasis follows

Ninety-three patients were treated by artificial pneumothorax, with fourteen (15 per cent) reported cured, forty-four were reported improved (varying from slight to really great improvement) Only seven patients were reported as having died, and of these, two died following thoracoplasty In twelve cases, pneumothorax could not be created There was a rupture into the pleural cavity in only three

In the patients who were cured the disease had existed for a length of time, varying from a few months to one year, with a few rare exceptions in which the disease was of two, three and four years' duration This bears out the point that every one recognizes, that if treatment is to produce satisfactory results, it should be established early

It seems extraordinary to us that of ninety-two patients, fifty-seven should be reported as improved by the treatment, and that it was impossible to enter the pleural cavity in only twelve

In the satisfactory cases in which a complete collapse could be brought about, the treatment was kept up for a period varying from five or six months to six years

A comparison of our own results with those taken from the literature is striking In cases of abscess of the lung we report only 2 patients of 18 (11 per cent) cured, whereas in 127 case reports collected from the literature, 66 (51 per cent) patients are reported cured In the cases of bronchiectasis, we report 1 cure out of 5, whereas of 92 cases taken from the literature, 14 (15 per cent) cures are reported In contrasting these figures, it should be borne in mind that it has been impossible for us to determine what the term "cured" meant to many of the reporters of cases Whether their patients have remained free from symptoms merely while under their observation or for a period of several years, we are unable to tell

If the statistics of cases of abscess of the lung which we have compiled from the literature are correct, and if we may expect a cure in 51 per cent or even in from 30 to 40 per cent of the cases in which this treatment is established early (at most three or four months from the beginning of the disease), it seems to us that this form of treatment should be used more frequently, in spite of our own experience of cure in only 11 per cent

We do not feel any great amount of confidence in the use of artificial pneumothorax in cases of bronchiectasis, although the literature reports a cure in 15 per cent of the cases, but we are willing to believe that in a rare case which is taken early and in which there are no adhesions, the patient may be cured We believe also that occasionally a patient may be kept almost free from symptoms for as long a time as a complete collapse of the lung can be maintained



patient was dismissed one month later as no improvement was noted. Examination two months later showed the patient to be in a fair condition. The amount of foul sputum had decreased. Pneumothorax was not demonstrable by the roentgen ray.

**Summary** This was an advanced case in which both lungs were affected and there were marked adhesions on the side on which operation had been performed, consequently there was only partial pneumothorax which resulted in a definite decrease of sputum. The improvement was slight. A subsequent history was not given.

The second case was that of a boy, aged 12, who had been ill many years and who had a long continued high fever. The process was on one side. The fingers were moderately clubbed. Ten insufflations were performed in four months. As a result, there was extensive pneumothorax without exudate, but there were two long, thin adhesions. The general condition was fairly good. Dyspnea was not present. Over the healthy lung in the lower part of the back were scattered moist râles. At the time this case was published, treatment was being continued.

**Summary** This was an old, one-sided case with moderate physical signs. Marked improvement occurred during a moderately long continued treatment by pneumothorax. Subsequent results were not known.

The third case was that of a woman, aged 38. One side of the lung had been affected for many years. Four insufflations were performed in nine weeks. As a result, the lung lay crumpled at the hilum. There was no exudate and little sputum.

**Summary** In this case of long standing one lung was affected, there were slight clinical and physical symptoms and little sputum was raised. Treatment by artificial pneumothorax brought about a good collapse of the lung and the expectoration of a slight amount of sputum. The subsequent history is unknown. The treatment was discontinued on account of diffuse pleural adhesions.

A pneumothorax could not be performed in the fourth case.

In 1910, Schmidt,<sup>3</sup> after an experience of five years, reported the treatment of eight patients with bronchiectasis and three with abscesses of the lung. He had treated some patients with infusions of oil and some with artificial pneumothorax.

In one of three cases of abscess of the lung, good results were obtained with artificial pneumothorax. There were four cases of bronchiectasis, three unilateral and one bilateral.

<sup>3</sup> Schmidt, A. Brauer's Beitr 9, no 3, 1908, Erfahrungen mit dem therapeutischen Pneumo- und Hydrothorax bei einseitiger Lungentuberkulose Bronchiectasien und Aspirations-Erkrankungen, Beitr z klin d Tuberk 9 261, 1908-1910.



In 1910, Wellman<sup>6</sup> reported the treatment of two patients with abscess of the lung. Although one patient recovered following the attempted pneumothorax, the recovery cannot be ascribed to this method of treatment, as the lung was never compressed, even though the last manipulation ended in the discharge by mouth of 1,200 cc of purulent sputum. In the other case, the pneumothorax had to be discontinued, and the patient was discharged convalescent.

A case of bronchiectasis was reported in a girl, aged 19. The process was one-sided. She had been ill for years following pneumonia. Fifteen insufflations were performed in slightly less than one year. There was diffuse pneumothorax. The lung lay at the hilum, there were several stringy adhesions to the diaphragm. Râles were not present fifteen months after beginning the treatment, and the gas had entirely disappeared. There were still numerous râles over the lower lobe of the left lung. One year after the collapse therapy was employed, the patient was still able to do her work.

**Summary** In a case of chronic pneumonia of long duration with slight bronchiectasis and no debilitation, marked collapse of the lung was obtained, and as a result the sputum disappeared. After pneumothorax had existed one year, it suddenly "went back" and could not again be produced. There was marked improvement. A similar condition existed one year later.

In 1912, Volhard<sup>7</sup> obtained good results in a case of bronchiectasis. A patient with abscess of the lung improved after pneumothorax, but later the abscess infected the pleura, and fatal empyema resulted. According to Volhard, one cannot reckon on the pleural cavity remaining sterile in cases of abscesses of the lung, for this reason, such cases are not adapted to treatment by the method of pneumothorax.

In 1910, Luxemborg<sup>8</sup> reported a case of a patient, aged 28, who had an infection on one side of the lung of one year's duration. Five insufflations were given in two and three-fourths months. There was partial pneumothorax. At times the sputum decreased, but it never disappeared entirely. Therefore, plastic operation of the thorax was performed, with good results.

**Summary** The partial pneumothorax of short duration was only slightly successful in this probably advanced case with cavities, at least outside the hilum.

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6 Wellman. *Klinische Erfahrungen in der Behandlung mittels kunstlichen Pneumothorax*, Beitr z Klin d Tuberk **17** 81, 1910.

7 Volhard. *Ueber den kunstlichen Pneumothorax bei Lungentuberkulose und Bronchiektasien*, Munchen med Wchnschr, Aug 6, 1912, no 32, p 1746.

8 Luxemborg, H. *Mitt a d Grenzgeb d Med u Chir*, 1910, vol 21.

Patterson, O. S. 1927  
 Jackson County Sanatorium  
 Middleton, Mass.

Five hundred cubic centimeters of nitrogen was withdrawn from the pleural cavity. Bronchopneumonia developed at the base of the lung, and the patient died. Autopsy showed that the upper and lower lobes of the right lung were collapsed. The middle lobe was converted into a mass of connective tissue about the abscess cavity. There was an area of bronchopneumonia at the base of both lungs. In 1912, Kellar<sup>11</sup> reported two unilateral and two bilateral cases of bronchiectasis with improvement in two of the cases as a result of artificial pneumothorax.

The first case was that of a man, aged 30, who had had a cough since his seventeenth year, when he had had pneumonia of long duration. He had dyspnea. Pneumothorax was applied to one side, which proved to be the one less involved. Shortly afterward, pneumothorax was applied on the right side. Several insufflations were given, but were not successful. The patient died soon afterward.

**Summary** The process occurred on both sides following pneumonia of long duration without marked clinical symptoms. A brief attempt to apply pneumothorax was not successful owing to pleural adhesions.

In the second case, a man, aged 31, had had a cough for three or four years. There had been considerable sputum in the last few months. On the left side there was a large pneumothorax. Six insufflations were given without any effect on the sputum. Then the patient gave up the treatment.

**Summary** A short compression of a rather lightly infected lung through a very large yet not complete pneumothorax did not have any effect on the symptoms of the double process.

In the third case, a girl, aged 18, had had a cough for one and one-fourth years. Blood was present in the sputum eight months before she consulted Dr. Keller. There was complete pneumothorax. The number of times artificial pneumothorax was performed was not given. At the time of the publication of the case, treatment was being continued. There was complete collapse. The cough and sputum ceased only when the patient was given new insufflations every four weeks.

**Summary** Total pneumothorax caused the disappearance of symptoms in this one-sided but severe process, and the patient was able to do full time work two and one-fourth years later. The results were good.

The fourth case was that of a man, aged 32, who had been coughing since he had had pneumonia of long duration four years previously. The amount of sputum and dyspnea increased. The number of insuf-

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<sup>11</sup> Kellar. Brauer's Beitr, 1912, vol 22, no 2, Erfahrungen uber den künstlichen Pneumothorax, Beitr z klin d Tuberk 22 165-242, 1912

or possibly the lower margin of the consolidated lung. A dulness was found throughout the lower half of the right side of the chest, and the appearance of gas was between the diaphragm and the liver.

On April 20, 600 cc of air was injected. The temperature dropped, but there was still considerable cough and sputum. A roentgen-ray examination showed partial collapse.

On April 24, 500 cc of air was injected. The patient's condition improved, and the cough and sputum decreased.

On May 1, 450 cc. of air was injected. A roentgen-ray examination on May 6 showed that the lung was completely collapsed. There were two areas in which the lung appeared adherent to the wall of the chest. On May 14, roentgen-ray examination showed that the diaphragm was apparently held up to the base of the lung by adhesion. Evidence of some subcutaneous emphysema was seen on the right side of the wall of the chest.

The patient was to report in two weeks.

On June 3, roentgen-ray examination showed the outline of the partially collapsed lung and the fluid level in the lower part of the chest.

On June 11, the chest was tapped, and 8 cc of slightly cloudy, straw-colored fluid was withdrawn. Roentgen-ray examination showed a definite area of dulness on the right side of the chest, which extended horizontally across the chest in the fourth interspace in front. The costal margin of the diaphragm appeared fixed. On rotation, the area of dulness appeared to be nearer the back than the front.

The patient died on July 1, 1921, of bronchopneumonia.

CASE 3—A N, a Polish woman, married, a housewife, aged 42, entered the hospital on Jan 6, 1923. She had had a pain in the right side of the chest for nine weeks, vomiting for four weeks and a cough for nine weeks.

A week before admission, she had swallowed a veal bone. The local physician recovered a small piece. Coughing and vomiting persisted so that the patient could not eat or sleep. The pain on the right side prevented her from lying on that side, the pain was worse on coughing. She expectorated foul, puslike sputum continuously and lost 35 pounds (15.9 Kg). The esophagus was not obstructed, and evidence of a foreign body was not found.

Physical examination showed that the expansion of the chest was equal. The upper sternum was prominent, the right axilla was slightly dull. There were a few fine râles low in the left axilla. Breath sounds and voice sounds were satisfactory.

On January 10, a roentgen-ray examination revealed dulness at the base of the right lung of mottled character with an indefinite outline which somewhat obscured the outline of the diaphragm. There were limited respiratory movements on this side. Root shadows on the right side were increased in size and in density. Markings running to the lower lobe also were prominent. The remainder of the fields of the lung were clear. The diaphragm on the left side was sharply defined, and the respiratory excursion was normal. There was no evidence of a cavity formation. The appearance suggested a rather extensive process of a pneumonic character involving the lower part of the lower lobe of the right lung.

On January 13, 500 cc of air was injected into the right midaxillary line, the needle was reinserted, and 100 cc more was given. A reaction did not occur. During the next three or four days there was much improvement and less coughing.

foul sputum. A complete collapse of the affected lung was induced, and the sputum was reduced to about 1 ounce daily. The patient had been under treatment for three months when examined. Three months later, he was in excellent condition, having only a slight cough and raising a small amount of sputum.

Izar also reported unsuccessful results in a young man, aged 19, with an abscess of the inferior lobe of the right lung. A partial pneumothorax was obtained, with the reduction of the sputum to one half. Attempts to collapse the lung where it was adherent posteriorly caused so much discomfort that the treatment had to be abandoned, leaving the patient in the same condition in which he entered the hospital.

In 1913, Singer<sup>17</sup> reported three cases in which artificial pneumothorax was attempted. He was unable to induce a pneumothorax in two cases on account of extensive adhesions.

In the third case, there was an extensive bilateral bronchiectasis with multiple loci. Marked improvement did not follow two injections of 1,000 cc of nitrogen into the left pleural cavity. Later injections were given on the right side, but no noteworthy change was noted.

In 1913, Angelini<sup>18</sup> reported unsuccessful results of pneumothorax therapy in a case of bronchiectasis of three and one-half years' duration. It was impossible to cause collapse of the lung even with high pressure on account of extensive adhesions. The patient became worse, and hemoptysis and pyothorax resulted from rupture of the cavity.

In 1913, Hochhaus<sup>19</sup> performed pneumothorax in four cases. In one there was marked improvement, in three, no improvement. Later results were not known.

In 1913, Pielsticker and Vogt<sup>20</sup> reported four cases of bronchiectasis in children aged 11, 6, 7 and 2, respectively. Treatments were unsuccessful in two of these cases because of adhesions, in one, the treatment was discontinued because of contralateral bronchitis and in the other because of the patient's refusal to continue treatment.

In 1914, Fornaca<sup>21</sup> reported the case of a woman, aged 40, with an abscess of one year's duration of the lower lobe of the left lung. The

17 Singer, G. Zur konservativen Behandlung der chronischen Lungenerkrankungen, Verhandl d Kong f Inn Med **30** 380, 1913, discussion by Brauer, Penzoldt, Singer, p 395.

18 Angelini, A. I risultati immediati del pneumotorace artificiale alla Forlanini nei malati di tubercolosi polmonare nell'ospizio, Umberto I in Roma, Riv osp no 2 913, 1913.

19 Hochhaus. München med Wchnschr, 1913, p 385.

20 Pielsticker, F. H., and Vogt, H. Ueber kunstlichen Pneumothorax bei Kindern. Kinderklinik Strassburg, Monatschr f Kinderh **11** 143, 1913.

21 Fornaca, L. Ascesso polmonare per ingestione e permanenza d'un corpo estraneo trattato e guarito col pneumotorace artificiale, Pensiero med, 1913 p 143.

On January 19, a resection of the second and third ribs was performed

On January 25, roentgen-ray examination showed a diffuse clouding about the upper half of the lung without definite evidence of a cavity

On January 30, a resection of the second, third, fourth, fifth and six ribs was performed On February 3, the wound became infected with streptococci and was opened and drained The patient died on February 9

Autopsy showed abscesses of the lung, atelectasis, bronchitis, chronic adhesive pleurisy and fibrosis of the lung

CASE 5—V G W, a woman, aged 31, white, married, American, without an occupation, was admitted to the hospital on April 28, 1923 Following an operation fourteen months before for suspension of the uterus, removal of an abscessed ovary and appendix, a dry cough developed Later thick, foul, greenish sputum was observed The patient was in the Rutland Sanitarium five months before for prevention of tuberculosis The sputum gradually increased Roentgen-ray examination on May 1 showed a definite area of mottled density obliterating the angle between the diaphragm and the right side of the heart A margin of the dull area was indistinct, and a definite cavity was not seen Both apexes and the left lung were clear A rather extensive pathologic process was seen near the right descending bronchus and confined to the lower lobe of the right lung, it was probably an abscess

Examination of the chest showed fluid at the base of the right lung in the back, extending from just below the angle of the scapula downward Tactile and voice fremitus and breath sounds were diminished over this area The rest of the lungs were clear

On May 10, 900 cc of air was injected into the fifth space in the midaxillary line on the right side On May 12, a roentgenogram did not show any evidence of pneumothorax On May 18, an unsuccessful attempt was made to inject air On May 21, an exploratory thoracotomy was performed by Dr Whittemore, who also resected the ninth rib When the pleural cavity was opened the lung collapsed and there were no adhesions The wound was closed without drainage, leaving the lung collapsed

On May 23, 450 cc of air was injected, and on the same date a roentgenogram showed the lung partially collapsed On May 25, 600 cc of air was injected The patient coughed less, and improvement followed On May 28, 550 cc of air was injected The foot of the bed was elevated, and the patient lay on his left side to help drainage A roentgen-ray examination on this date showed the upper and middle lobe completely collapsed The lower lobe appeared to be adherent along the diaphragm or in the axillary line close to the diaphragm

On June 1, 600 cc of air was injected There was considerable coughing at the end of the injection and the sputum was becoming thinner

On June 5, 250 cc of air was injected The treatment was stopped because the patient coughed considerably while it was being given There was a great deal of air in the tissues A roentgen-ray examination showed practically the same condition as before without evidence of fluid in the tissue

On June 13, 650 cc of air was easily injected On June 22 575 cc was injected, during the injection, there was an annoying cough On July 9, phrenic neurotomy was performed by Dr Porter to paralyze the right side of the diaphragm and to help to collapse the right side of the chest Roentgen-ray examination on July 13 showed that the right side of the diaphragm was much higher It reached the level of the fourth rib at the sternal end of the fifth and ninth interspaces behind There was a suggestion of fluid in the costophrenic



The third case was that of a girl with an abscess of the lower lobe of the right lung. In all these cases complete collapse was possible and was maintained with successful results.

In 1914 Lemann and Maes-Urban<sup>25</sup> reported a case of bronchiectasis in a colored girl aged 11, the abscess cavity being located in the lower lobe of the left lung. The lung was being kept completely collapsed at the time of the report, the patient was up and about and almost free from sputum.

In 1914, Webb and Gilbert<sup>26</sup> reported two cases of abscesses of the lung (secondary to the aspiration of a foreign body). One patient was apparently cured, the other died, probably as a result of his weakened condition.

In 1914, Zinn<sup>27</sup> described marked improvement in three patients with bronchiectasis who were treated with pneumothorax. In the first case, a man, aged 43, had bronchiectasis of the lower lobe of the left lung, complete collapse was obtained. At the time of the report two years later, the patient was without cough or symptoms and a roentgen-ray examination did not show any pathologic process in the reexpanded lung. The second case was that of a man, aged 50, who had bronchiectasis of the lower lobe of the left lung, complete collapse was maintained for months. Fifteen months after the last injection the patient was well, having no cough or symptoms. The third case was that of a woman aged 29, who had bilateral bronchiectasis, more extensive on the right side. Complete collapse of the right lung was maintained for five months, with marked improvement.

The first and second cases occurred early. The third case was an old chronic one. Zinn believed pneumothorax therapy to be a logical treatment if employed before the tissues become completely rigid.

In 1914 Matson<sup>28</sup> reported the case of a young woman with an abscess of the lower lobe of the right lung following tonsillectomy. At the time treatment was started, she was raising 500 cc of foul sputum a day. The treatment was continued for eight months, and at the time of the report she was well.

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25 Lemann, J. J., and Maes-Urban. Artificial Pneumothorax in the Treatment of Lung Abscess, New Orleans M. & S. J. **67** 328 (Oct.) 1914.

26 Webb and Gilbert. National Assn. Tuberculosis, 1914.

27 Zinn, W. Ueber die Pneumothorax Behandlung von Bronchiektasien, Die Therapie der Gegenwart, Berlin **16** 337-344, 1914.

28 Matson, Ralph C. The Treatment of Pulmonary Tuberculosis by Means of Artificial Pneumothorax, Northwest Med. **6** 10, 1914, Clinical Observations on Artificial Pneumothorax with Report of Seventy-Three Cases, Discussions, Nat. Assn. Study & Prev. Tuberc. **40** 175 and 199, 1915.

ray examination did not show any evidence of air in the chest. On February 21, 700 cc of air was injected without results. On February 26, 900 cc of air was injected, on February 27, roentgen-ray examination showed evidence of air in the base of the right lung, the axillary border and the apex, but the area of pathologic process showed little collapse. On March 1, 500 cc of air was injected, and on March 3, roentgen-ray examination showed definite bands (adhesions) extending through the partially collapsed wall of the chest in the axillary margin. Mild pain was felt on the right side of the chest, but the patient did not cough so much.

On March 17, an area of almost complete dullness was felt on the right side below the level of the fifth rib posteriorly, above this region, there were increased radiance and absence of lung markings. On March 19, the chest was tapped, and purulent, thick, foul pus was found. The temperature had been rising for the last few days. On March 24, trocar thoracotomy for acute empyema was performed by Dr. Churchill. A considerable amount of foul pus was aspirated. The temperature was lower for three days and then rose again. Irrigation was performed, and there was considerable return from aspiration.

On March 29, roentgen-ray examination showed the lung distinctly collapsed with apparently complete absence of air, however, it occupied a considerably larger area than was usually seen after complete collapse. Fluid was not present. The heart was displaced to the left. On April 12, the temperature was still high, irrigation was unsatisfactory, and the patient's condition was not improving. There was epigastric pain and occasional vomiting.

On April 23, resection of the eighth rib was performed. An old sinus extending through the wall of the chest was enlarged, and a large rubber tube and two Dakin tubes were inserted into the long empyema cavity by Dr. W. Whittemore. Saline irrigations were used. On April 24, a surgical transfusion was given. On April 27, the patient felt better, vomiting had stopped and the epigastric pain was diminished. The patient was gaining perceptibly and the temperature was down to almost normal on May 2. On May 9, roentgen-ray examination showed dullness throughout the lower half of the right lung and along the axillary border to the apex. A dense shadow was seen in the lower part which was probably fluid. There was a bright area in the region of the bronchus and another just below it with indefinite lines running across. The left lung was normal.

On May 10, the temperature had risen again for a few days and on May 14 irrigation with surgical solution of chlorinated soda was started. On May 30, the patient was gaining slowly. Irrigation was continued. On June 8 a roentgen-ray examination showed that the lung was not more collapsed than before. On June 11, all of the tubes were removed and one small Dakin tube put back. On June 17, the patient was discharged from the hospital.

In January, 1924, the patient stated in a letter that she was well.

CASE 8—G. B., a white man, aged 33, Italian, married, a chipper, was admitted to the hospital on June 26, 1923. He had had intermittent pain of sixteen months' duration in the right side of the chest in the area covered by the fourth to the tenth ribs anterior to the anterior axillary line. The onset occurred with a sudden attack of pain without an initial chill or hemoptysis. The patient was in bed for two days, then resumed his work for three days, but was forced to stop on account of pain. He was then in bed for three months. His temperature varied between 102 and 103 F., and he had intermittent chills and sweats. There was no history of the inhalation of a foreign body or of an operation. Cough began with pain and did not show any relation to a change of position.

Wagner also reported the case of a girl, aged 15, who developed bronchiectasis in the lower lobe of the left lung following pneumonia and empyema. Seven insufflations were given in the course of a little more than two months. Four months after applying pneumothorax and three weeks after the last insufflation, the sputum had entirely disappeared, there was marked improvement. Later results were not known.

In 1915, Reichmann<sup>32</sup> reported the case of a woman, aged 30, with a gangrenous process involving two thirds of the lower lobe of the left lung. She was raising a large quantity of foul sputum containing elastic fibers, but tubercle bacilli were not found. The patient was given five large injections of nitrogen during eleven days, following which she made steady improvement and gained in weight. A month later she was in good condition, the cough and sputum having entirely disappeared.

Lindvall<sup>33</sup> reported the case of a woman, aged 33, who had an abscess of the upper lobe of the right lung. She raised 150 cc of foul sputum a day. She had a strongly positive Wassermann reaction and pneumothorax and injections of mercury were given from November to February, and the patient had been well for several months when the report was published.

In 1916, Dahlstedt<sup>34</sup> reported one case of bronchiectasis of long standing. The case was that of a boy, aged 13, who had had pertussis at the age of 3. Since then there had been a continual expectoration of a yellow-green sputum. The general condition of the patient was good, although there was slight cyanosis. Complete pneumothorax was obtained, the number of insufflations and duration of the treatment was not given. The patient did not come regularly for treatments.

In 1916, Cappeller<sup>35</sup> reported two cases. In the first case there was a fresh infection on one side and considerable foul sputum. Pneumothorax was maintained for one month, the cough disappeared and no more sputum was raised. Later results were not known. The condition was on one side also in the second case. The duration was unknown. Five insufflations were given in the course of fourteen days. The results were negative.

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32 Reichmann, V. Cure of Gangrenous Process of Lung by Artificial Pneumothorax, *Munchen med Wchnschr* **62** 946 (July) 1914.

33 Lindvall, H. Case of Syphilitic Abscess of the Lung with Favorable Course Under Combined Pneumothorax and Mercury Treatment, *Hygiea* **77** 1025, 1915.

34 Dahlstedt, H. *Nord med Ark*, 1916, no 3, vol 49.

35 Cappeller, W. Beitrag zur Pneumothorax Behandlung spezielle de Bronchiektasien und der Brustfellohlenergüsse. In *aug diss*, Jena, 1916.

Artificial pneumothorax was unsuccessful

An operation was performed on August 15 by Dr Whittemore. An incision was made for resection of the third rib and drainage of the abscess of the lung. On August 21, the condition was greatly improved, the temperature was lower, and the patient coughed less. On August 29, he was gaining rapidly; there was very little drainage, and the wound was in a satisfactory condition. On September 7 he was discharged to the outpatient department.

CASE 11—L. D., a white woman, aged 37, Jewish, married, a housewife, was admitted to the hospital on March 6, 1923. Tonsillectomy had been performed one week previously. Since that time the patient had been nauseated, had chills, a headache, and a cough with sputum, later the sputum was white and mucoid, with a foul odor. She had had a sharp, nonradiating pain in the right side of the chest for the last twenty-four hours. Her temperature varied between 99.4 and 101 F.

Examination of the chest revealed many fine to moderate crackling rales with possibly some friction rubs in the lower third of the right side of the chest extending part way into the axilla. Breath sounds tended to be bronchovesicular without a definite increase in the whispered or spoken voice. Dulness was not demonstrable on percussion. Roentgen-ray examination on March 13 showed an area of dulness on the right side of the middle part of the chest. The area was relatively circular in outline, and appeared nearer the root than the periphery of the lung, and was merged with dulness at the root. Within this area, there was a distinct area of increased radiance with an irregular convex upper border and a regular horizontal lower border. The density was much greater below than above. The symptoms were characteristic of abscess of the lung, and there was a large cavity containing fluid.

Artificial pneumothorax was instituted on March 15, 500 cc of air being injected into the postaxillary line, fourth interspace, right side, under light pressure. Free pleural oscillations were from  $-3$  to  $-1$  cm before injection,  $-2$  afterward. The patient coughed twice. Roentgen-ray examination on March 15 showed a partial collapse and a narrow area of pneumothorax in the axillary line and probably at the apex, but the immediate region of the abscess showed little collapse and a sharp and definite border.

On March 18, 500 cc of air was injected, the pressure was from  $-4$  to  $-1$  at the start and from  $-2.5$  to  $+1$  at the end. Roentgen-ray examination on March 19 showed that the right lung was a little more collapsed with air in the base along the axillary line and probably at the apex, but the immediate region of the abscess was little collapsed and showed a sharp and definite border.

On March 22, 500 cc of air was injected with difficulty because of the cough. The pressure was  $-5$  on inspiration at the start, 0 to  $+2.5$  at the end. Roentgen-ray examination on March 23 showed little compression of the lung in the region of the abscess. About one half of the space of the lung was filled with air.

On March 26, 450 cc of air was injected with ease, as the patient did not cough, with the pressure from  $-2$  to  $+1$  at the start and from 0 to  $-4$  at the end. Roentgen-ray examination on March 29 showed the lung completely surrounded by air and fairly well collapsed.

On March 31, 550 cc of air was injected with ease, as the patient did not cough. The pressure was  $-6$  at the start and  $+1$  at the end. Roentgen-ray examination on April 2 showed the right lung to be practically free from air. The cavity of the abscess was still visible and seemed a little smaller. There were bands of increased density running from the upper portion of the involved area across the chest to the axillary margin in the region of the third rib. Roentgen-ray

tuberculous lung by pyogenic organisms. After eleven injections which maintained almost complete collapse of the lung, the patient was reported as experiencing marked abatement of the foul sputum, fever and cough, and to be gaining in weight and strength.

In 1918, De Verbizier and Loiseleur<sup>42</sup> reported the successful treatment of a soldier, aged 19, who had an abscess cavity of the lung and a fluid level which resulted from influenza pneumonia. The patient was given 1,000 cc of nitrogen in two injections, obtaining a positive pressure of 4 cm. There was immediate improvement, and three weeks later, the patient was well and free from symptoms.

Weil<sup>43</sup> reported three cases of abscess of the lung. In the first case, two injections of nitrogen were given at five day intervals, and the patient was reported cured. In the second case, the patient improved, but later died of pericarditis and serous pleurisy. The third case was that of a soldier, aged 19, who had a chronic bronchiectatic cavity of the lower lobe of the right lung. A rather large amount of nitrogen was injected as follows: On September 12, he was given 500 cc, on September 14, 2,000 cc, on September 20, 2,000 cc, and on September 27, 2,400 cc. Complete collapse of the lung was obtained with the exception of adhesion at the diaphragm. The injections were unusually large to be given at such short intervals, and the patient must have had a very large pleural cavity. On December 9, the lung was completely reexpanded, the patient raising some mucopurulent sputum, but feeling well.

Bergman<sup>44</sup> treated five patients for abscess of the lung, three were cured in two months, in one patient the cavity could not be drained, and one patient died.

In 1919, Unverricht<sup>45</sup> reported seven cases of bronchiectasis, the first case was that of a woman, aged 22. Three years previously she had had pneumonia on the right side. For one and one-half years the sputum had been very foul. Seven insufflations were given in the

42 De Verbizier and Loiseleur. *Gangrene pulmonaire traitée et guérie par le pneumothorax artificiel*, Bull et mem Soc med d hôp de Paris **42** 1139, 1918.

43 Weil, P. E., and Loiseleur. *Le traitement de la gangrene pulmonaire par le pneumothorax artificiel*, Paris méd **33** 180, 1919, *La gangrene pulmonaire et ses nouvelles méthodes de traitement*, Monde med **29** 391, 1920, *Le traitement de la gangrene pulmonaire par production de pneumothorax*, Bull Acad de med, Paris **80** 393, 1918, *Le pneumothorax artificiel dans la dilatation des bronches*, Bull et mem Soc med d hôp de Paris **46** 655, 1919.

44 Bergman, H. *Für die Pneumothoraxbehandlung des Lungenabszesses*, Deutsche med Wchnschr **45** 970, 1919.

45 Unverricht, W. *Ueber Behandlung von Bronchiectasis mit künstlichem Pneumothorax*, Berl klin Wchnschr **56** 516, 1919, *Ztschr f phys u diätet Therap* **23** 393, 1919.

in the left axilla. The breath was foul. The temperature was 100 F, and the pulse rate, 98. There was slight dullness at the base of the right lung.

Examination showed a few râles when the patient coughed.

Roentgen-ray examination on March 3 showed dullness in the base of the right lung that extended more than half way across the left field, but did not reach the shadow of the diaphragm. The upper part of this area was partially obscured by the shadow of the heart and of the ribs. There was a small, rounded, relatively light area which may have represented a cavity. There was no definite fluid level. The whole appearance was suggestive of an abscess.

Roentgen-ray examination on March 15 showed the process slightly more circumscribed. A definite cavity was not made out, but there was some dilatation of the bronchial tree.

On April 30, the patient was discharged and placed in the care of a local physician. She remained in good condition for about a month, then began to be short of breath and raised a considerable amount of sputum.

On June 11 and 15, she was given 500 cc of air as an artificial pneumothorax. On June 17, there were signs of fluid in the right side of the chest, and aspiration showed a thin pus.

On June 23, she returned to the hospital. On entrance, she was breathing rapidly, and was flushed and restless. She complained of pain in the right side of the chest. Percussion over the base of the right lung elicited dullness to flatness; in this area, the breath sounds and fremitus were diminished to absent. The needle was inserted and a cloudy fluid was evacuated which had the appearance of pus. Trocar thoracotomy was performed. The patient made a fairly good convalescence, and was discharged from the hospital on August 4.

On September 6, she returned to the hospital, cough and sputum had increased. On September 8, the chest was again aspirated, but fluid was not obtained. On September 11, a resection of the rib was performed, and on September 30, the patient was discharged from the hospital with a small drainage tube in the old empyema sinus.

A follow-up note, dated August 21, stated that the tube had been removed three months before, and that the patient had been well ever since. The patient was seen on March 8, 1927. She had the appearance of a fat, healthy girl and did not have a cough or symptoms.

CASE 14—A. C., a boy, aged 11, was admitted to the hospital on Oct. 5, 1926, he had had a cough and raised sputum for six or seven months. Roentgen-ray examination showed an abscess of the upper lobe of the left lung. On October 8, 11 and 14, artificial pneumothorax was performed, 800 and 500 cc of air being injected, respectively. During the next few days the patient's temperature was higher than it had been, and signs in the chest were suggestive of fluid.

On November 8, the chest was aspirated and pus was removed. On November 9, a trocar thoracotomy was performed. On November 23 roentgen-ray examination showed capsulated fluid about the region in which the chest was previously opened. On December 10 aspiration was performed through the third inter-space axillary line, and pus was obtained. Trocar thoracotomy was performed in this region.

On December 14, the patient was discharged with pus draining from two incisions. On March 9, 1927, the patient's general condition was greatly improved; the amount of sputum had decreased and the temperature did not go above 99 F. The lower wound was closed and there was only a small amount of drainage from the upper one.

In 1922, Rist <sup>46</sup> reported ten cases of bronchiectasis. Case 1 was that of a girl, aged 5½ years. Bronchiectasis had developed in the base of the left lung following measles and bronchopneumonia two and one-half years previously. Pneumothorax therapy was given for eight months. As a result, the fever, cough and sputum quickly disappeared. Five years later the patient was cured, and remained well eight years after the end of the treatment.

In the second case, a woman, aged 34, had typical bronchiectasis. One and one-half years later pneumothorax was attempted, without beneficial results.

In the third case, a man, aged 21, developed bronchiectasis following pneumonia. Three years later pneumothorax was unsuccessful. The fourth case was that of a man, aged 29. After severe pneumonia in February, 1920, induration of the left lung developed accompanied by bronchiectasis. In September, 1921, pneumothorax was tried with partial collapse. The results were negative. The patient felt marked discomfort when the pressure was increased. The treatment was discontinued.

In the fifth case, a girl, aged 19, had had pertussis at 3½ years of age, followed by bronchiectasis. Partial pneumothorax was obtained without beneficial results.

In the sixth case, a boy, aged 9, had double bronchopneumonia following measles at 2 years of age. Since then he had had symptoms of bronchiectasis. Pneumothorax was complete.

Summary. This was an old one-sided case in which good results were obtained.

In the seventh case, a boy, aged 13, had had pneumonia in the left lung in 1920. Bronchiectasis of the lower side of the left lung developed. Treatment by pneumothorax was given, resulting in complete collapse. In March, 1922, the patient was still under treatment.

The eighth case was that of a boy, aged 15, in whom, after influenza and pneumonia in October, 1918, bronchiectasis developed at the base of the left lung, accompanied by fever and dyspnea. In April, 1920, pneumothorax brought about complete collapse. The symptoms disappeared in a few weeks. At the time that this article was written, the patient had been working one year, and the treatment was being continued.

Summary. This was a recent severe case with complete pneumothorax, cure was obtained.

The ninth case was that of a man, aged 24, who since childhood had had two bronchiectatic cavities of the lower lobe of the right

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<sup>46</sup> Rist, E. Un cas de bronchiectasie guérie par le pneumothorax artificiel, *Bull et mem Soc med d hôp de Paris* **43** 652, 1919, Le traitement des dilata-tions bronchiques par le pneumothorax artificiel, *Bull med* **36** 246, 1922.





Brunning <sup>51</sup> reported the case of a man, aged 38, who had an abscess of the right lung following pneumonia. He received five injections during two months, totaling 5,600 cc of air, which did not completely collapse the lung on account of adhesions. Four more injections were given, and later severe pain with dyspnea and cardiac distress occurred. The pleural cavity was aspirated, and foul smelling pus was found. Resection of ribs showed empyema accompanying gangrene of the lung. Death occurred.

Gilbert <sup>52</sup> reported three cases of abscess of the lung. Eight treatments were given in the first case, partial collapse was obtained, and further treatment was unwise. A rib resection for drainage of the abscess was performed later, followed by complete recovery.

In the second case of abscess of the lung, partial collapse was obtained with relief from symptoms. Pyothorax developed, drainage resulted in some improvement.

The third case was that of a child, aged 8, with an abscess of the lower lobe of the right lung, due to the aspiration of a tooth. Complete collapse was maintained for eight weeks. The child was reported well two months after complete reexpansion of the lung.

Dumitresco-Mante <sup>53</sup> reported a case in a patient, aged 32, who had right interlobar empyema, profuse vomiting and foul sputum. He was treated by artificial pneumothorax for four months, with marked improvement, although the sputum was still foul. He was given three doses of neoarsphenamine and 2,000 cc of nitrogen. The condition improved, and the patient began to gain weight, later, he was reported well.

Dumitresco-Mante also mentioned another case of a man, aged 30, who had interlobar empyema of the right lung. After the first injection of nitrogen, the patient began to have severe hemoptysis, fever and severe general disturbance. The injection of nitrogen was stopped. Dumitresco-Mante thought that adhesions produced an uneven collapse, blocking the exit of the pus, thus giving rise to the disturbance.

Amaudru <sup>54</sup> reported a case of a woman, aged 36, who had an abscess of the lung following a phlebitis, and was in a serious condition on account of hemorrhages and foul sputum, complete collapse was obtained.

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51 Brunning, F. *Gegen die Pneumothoraxbehandlung des Lungenabszesses*, Deutsche med Wchnschr **45** 734, 1919.

52 Gilbert, O. M. *Artificial Pneumothorax in Acute Pulmonary Abscesses*, Colorado Med **18** 138, 1920.

53 Dumitresco-Mante. *Pleuresie interlobaire traitee par le pneumothorax artificiel et neosalvarsan intraveineux*, Bull et mem Soc med d hop de Paris **44** 1215, 1920.

54 Amaudru, J. *Plebite variequeuse, embolies, Abscess du poumon consecutive, guerison rapide par le pneumothorax therapeutique*, Bull et mem Soc. med d hôp de Paris **44** 1380, 1920.

CASE 20—L M, a white man, aged 25, Irish, single, a messenger was admitted to the hospital on May 15, 1923. Five years previously he had had influenza, pneumonia and pleurisy and had been in bed almost all winter. Since then the cough and the sputum had gradually increased. The sputum was greenish yellow, a cup full was expectorated in the morning, but it was never bloody or particularly foul. The patient had infantile paralysis at the age of 12 or 13 years, and this condition remained for fifteen years. He had a disease of the stomach for nine years.

Examination revealed a pathologic process in both lungs. The fingers were clubbed, and the patient was cyanotic. Roentgen-ray examination on May 16 showed increased density in the region of the left descending bronchus and the outline of bronchi mottled with a suggestion of dilatation of small bronchi. On the right side, there was increased density about the hilum and general peribronchial thickening. The appearance suggested bronchiectasis. The apices and the periphery of the lungs were normal. Roentgen-ray examination on May 17 also showed many bronchopneumonic patches scattered through both lungs with one large area in the upper left side of the chest. The areas were most dense in the center and gradually faded toward the periphery.

Artificial pneumothorax was attempted on May 20, but a pleural space was not found. On May 21, 150 cc of air was injected into the left anterior axillary line, in the sixth space, with a pressure of +4. On May 22, roentgen-ray examination showed a small gas bubble above the diaphragm on the left side; otherwise there was no evidence of air. On May 23, roentgen-ray examination and the high pressure which resulted from a small injection of air indicated that probably there was no pleural space. As the patient was in poor condition and as the process was bilateral, treatment was discontinued.

CASE 20—M R, a white man, aged 50, a Russian teamster, a widower, was admitted to the hospital on June 20, 1923. He gave a history of persistent cough for many years. Two years previously he had had several teeth removed under ether anesthesia. Shortly afterward the symptoms increased. He raised sputum, but not in an excessive amount. Two months after the extraction, he missed a tooth from his plate, but did not think that he had swallowed it. In March, three and a half months before admission he had a sudden attack of pain, the sputum increased greatly and became foul.

Examination of the chest revealed a localized process at the base of the left lung showing slight dulness. Tactile and voice fremitus were diminished and respiratory movements were much diminished. Moderate coarse moist inspiratory rales were heard. The nails were clubbed. Roentgen-ray examination revealed a pathologic process at the root of the left lung which involved the surrounding structure of the lung and which interfered with the passage of air. Encapsulated empyema and bronchiectasis would not account for the entire picture. The condition might have been abscess of the lung. A chronic disease of the lung should be considered.

Artificial pneumothorax was performed on June 28. 400 cc of air were injected into the left side. On June 30 roentgen-ray examination showed a suggestion of a small amount of air in the extreme apex of the left lung. Air was seen in the subcutaneous tissues in the left side of the chest. The collapse was noted.

On July 3 700 cc of air was easily injected. Roentgen-ray examination on July 6 still showed a small amount of air in the apex of the left lung. On July 7 further collapse. On July 7 air was injected. There was considerable subcutaneous emphysema. Subjectively the patient was much better. On July 10

Rich<sup>60</sup> (1922) reported some interesting results in ten cases of acute abscesses of the lung

A patient with an abscess of the upper lobe of the right lung was treated for twelve days with four small injections of air, totaling 900 cc. He was reported well and free from symptoms six months later

Another case was that of a man, aged 48, who had an abscess of the upper lobe of the right lung, or an interlobar empyema. He was given 275 cc of air, and a large amount of pus was evacuated at once. A second attempt to give air caused a slight pleural shock, so gas was not given. The patient left the hospital two weeks later, free from symptoms

In another case of abscess of the lung following appendectomy, the patient improved after the injection of 350 cc of air, he then died of asthema

In a fourth case, the patient had an abscess of the lower lobe of the right lung, or an interlobar empyema. He was given 550 cc of air, a large amount of pus was expectorated, and a second injection was given seven days later. The patient was reported well

In cases 7, 8 and 10, pneumothorax resulted in partial collapse with improvement

Two patients recovered spontaneously

In one case, pneumothorax was impossible, and surgical drainage was followed by death

In 1921, Ribara<sup>61</sup> reported the case of a young man who developed a bronchiectatic cavity with a diameter of 10 cm after influenzal bronchopneumonia. Marked improvement resulted after pneumothorax therapy (duration and amount not given). Later results were not known

Singer<sup>62</sup> reported the case of a patient with a bronchiectasis of two years' duration, who was raising a quart of pus a day. Following three severe hemorrhages, the lung was collapsed. The patient did not have further trouble

Singer and Graham<sup>63</sup> reported two cases of bronchiectasis of several years' duration. One patient was a boy, aged 17, partial pneumothorax brought some relief. The cavity in the lower lobe was not collapsed. Lobectomy was performed, and the patient recovered

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60 Rich, H. M. Acute Lung Abscess Treated by Therapeutic Pneumothorax, *Am J M Sc* **164** 428, 1922

61 Ribara, A. *Bol d clin*, 1921, no 7, vol 38, Ref I *Zentralbl f The forsch* **16** 559, 1922

62 Singer, J. J. Pneumothorax in Tuberculosis and Bronchiectasis, *J Missouri M A* **19** 89, 1922

63 Singer, J. J., and Graham, E. A. The Newer Treatment of Bronchiectasis, *J Missouri M A* **19** 390 (Sept) 1922

pleural cavity contained a considerable amount of air and pus. On January 28 sections of the upper six ribs were removed under gas-oxygen anesthesia. On February 2, the patient died.

CASE 22—P. M., a girl, aged 17, was admitted to the hospital on Aug. 6, 1926, with a diagnosis of bronchiectasis of the lower lobe of the left lung following what was probably bronchial pneumonia seventeen months before. She had a cough and raised from between 8 to 12 ounces (236 to 355 cc.) of purulent sputum. On August 8, roentgen-ray examination showed a dull area in the lower portion of the left side of the chest. The dullness was of a mottled character, extending up along the crest of the bronchial tree. The diaphragm was high on this side. The intercostal spaces were narrow. The heart and mediastinal contents were displaced to the left. The appearance was that of a chronic destructive process involving the lower lobe of the left lung.

On August 24, bronchoscopy was performed and iodized oil 40 per cent was injected. A roentgen-ray examination showed many discrete cavities in the lung tissue filled with the oil.

On September 6, artificial pneumothorax was given, 600 cc. of air being injected. On August 8, 600 cc. of air was injected, on August 12, 800 cc., and on August 20, 400 cc. Roentgen-ray examination on October 2 showed that the lung was completely collapsed. On October 25, the patient was discharged. Artificial pneumothorax was continued after the patient left the hospital.

On Feb. 24, 1927, bronchoscopy was performed. A small amount of pus was aspirated from the bronchus going to the lower lobe of the left lung. There was no evidence of collapse of the bronchi.

The patient said that she raises about 1 ounce (30 cc.) of sputum a day. She is in good physical condition. The lung is still collapsed.

In 1903, Riva-Rocci<sup>1</sup> reported the successful result of pneumothorax therapy in two cases. The first case was that of a boy aged 11 who had an extensive bronchiectasis of the right lung of four years' duration. The second case was that of a man, aged 28, who had an abscess of the upper lobe of the right lung of three months' duration, while under observation, he developed a valvular pneumothorax which nearly proved fatal. He was successfully treated by injecting nitrogen into the pleural cavity, collapsing the lung.

In 1908, Brauer<sup>2</sup> reported four cases of bronchiectasis in which the patients had the disease many years, three of whom improved after the treatment by pneumothorax.

One case was that of a girl, aged 16 who had bronchiectasis on both sides. She had been ill three years, and had fever and hemorrhages. In the course of twenty days three insufflations were performed, which gave a definite but partial pneumothorax. There was a slight exudate. Three weeks later thoracotomy was performed with resection of a rib and loosening of several strong adhesions. The

1 Riva-Rocci: *The Therapeutic Application of Artificial Pneumothorax*. *Gaz. med. ital.*, no. 27, July 2, 1903, p. 261.

2 Brauer: *Die therapeutische Bedeutung des künstlichen Pneumothorax*. *Klin. therap. Wchnschr.*, July, 1908, no. 28, p. 794.

injections were followed by hemoptysis and discontinued, surgical drainage afforded relief, but was attended by a persistent sinus

The second patient developed empyema twenty-four days after collapse had been induced. He died a month later after developing signs of pneumothorax on the untreated side

Pelle<sup>69</sup> reported the case of a patient with an interlobar empyema, who was cured after five months' treatment with artificial pneumothorax

By four injections of air, Troisier and Gayet<sup>70</sup> completely cured a patient with postpneumonic interlobar empyema communicating with a bronchus. The expectoration disappeared completely, and the temperature fell to normal after the second insufflation

Perkins and Burrell<sup>71</sup> cited seven cases of abscess of the lung and six cases of bronchiectasis to show the value of artificial pneumothorax in these conditions. Three patients with abscess were completely cured after treatment was continued from five to fourteen months. Two cases were complicated by rupture into the pleural cavity, one four days and the other three months after the institution of treatment, however, both patients made a complete recovery after drainage. One patient showed improvement in the general condition with a reduction of sputum, and complete recovery followed a thoracoplasty performed because of adhesions. In the remaining case, the collapse was incomplete because of adhesions, but the sputum was reduced from 7 to 2 ounces (from 207 to 59.2 cc). Death followed surgical drainage

Of the six patients with bronchiectasis, one is reported cured, two have shown marked improvement and are still under treatment, two showed a temporary improvement, but died following thoracoplasty performed because of adhesions, the condition of one patient with a bilateral case did not show any noteworthy change following successive collapses of the two sides

Harrell<sup>72</sup> treated an extremely ill patient by collapse during a period of thirteen weeks. At the end of a year, she was afebrile and in good condition, except for slight cough and some persistent expectoration. Harrell believed that in "all cases of pulmonary abscess, especially in extremely ill patients, pneumothorax should be given or tried before more radical procedures"

69 Pelle, M. A. Pneumothorax thérapeutique au cours d'une pleurésie interlobaire, *Bull et mem Soc med d hôp de Paris* 47 754, 1923

70 Troisier and Gayet. La cure de la pleurésie interlobaire et des suppurations pulmonaires par le pneumothorax thérapeutique, *Bull et mem Soc. med d hôp de Paris* 47 867, 1923

71 Perkins and Burrell. Artificial Pneumothorax. Its Application to Cases Other Than Those of Pulmonary Tuberculosis, *Lancet* 1 478 (March 10) 1923

72 Harrell, C. L. Report of a Case of Pulmonary Abscess of Lower Lobe Treated by Artificial Pneumothorax, *Virginia M. Monthly* 49 585, 1923

In case 1 the condition was chiefly on one side and of several years duration. Application of pneumothorax was not successful.

In the second case, the condition was chiefly on one side. The patient had been ill for many years. Pneumothorax was not successful.

In the third case, also, the condition was chiefly on one side. The duration of the illness was not given. Only one insufflation was given and the patient did not return for further treatment. The results were negative.

In the fourth case, both sides of a patient, aged 18, were affected. The duration of illness was not known. There was alternating pneumothorax during two or three weeks. Several months later three insufflations were given on the left side. After two and three-fourths months the left lung entirely collapsed and the râles disappeared but the sputum remained unchanged. One month after treatment, the lung was re-expanded and râles were heard again. This was probably an advanced case. Despite complete collapse of the lung the results were negative.

In 1910, Forlanini<sup>4</sup> reported a case of abscess of the lung in a woman, aged 24, who was cured. The abscess followed a croupous pneumonia and was of six years' duration. The patient was under treatment for fifteen months in 1904 and 1905 and when the case was reported, she had been in excellent condition for four years having a fully re-expanded lung.

Forlanini mentioned that he successfully treated one patient with bronchiectasis. Later reports were not given.

In 1910, Oscar Frank and von Jagie<sup>5</sup> reported the case of a patient, aged 28, with a double infection. Internal treatment for more than one year was unsuccessful. The patient was cyanotic and slightly dyspneic. He had clubbed fingers. Five insufflations were given in one month, and a large but only partial pneumothorax of the right side was obtained. The condition improved considerably, the dyspnea disappeared. There was marked improvement in the clubbed fingers. The râles practically disappeared and the cavities distinctly decreased in size. The patient was still under treatment when the report of the case was published.

**Summary.** Despite the short treatment with only partial pneumothorax, in this case of double infection which probably was not of long standing decided improvement was noted. The subsequent history is not known.

4 Forlanini C. Lung Abscess of Six Years Duration Successfully Cured by Artificial Pneumothorax. *Gaz med ital* March 10-17 1910 no 16 11 p 41.

5 Frank and Jagie. Ueber Pneumothoraxtherapie bei Bronch. *Wien klin Wchnschr* 1910 no 21 p 771.

1919, with a diagnosis of postpneumonia and nontuberculous induration of the lung with bronchiectasis. On May 23, artificial pneumothorax was applied to the right side. At the second insufflation, 500 cc could be given. Nineteen insufflations were given, the last on December 16. Only partial pneumothorax was obtained. The hemorrhages stopped. The sputum and cough decreased. On December 31, there was a sudden rise of temperature. Râles appeared at the bases of both lungs, and after continued high temperature, the patient died on Jan 2, 1920. Autopsy showed a bronchopneumonic area in the center of the lobe of the left lung, a slight amount of exudate was present in the cavities, but there was no evidence of tubercle bacilli.

The fifth case was that of a woman, aged 20. In June, 1920, pain developed in the right side of the chest, but there was no fever. In August, she coughed up a tablespoonful of blood. The sputum was foul. On Nov. 10, 1920, she entered a sanatorium. On December 2, pneumothorax was applied and continued until Oct 29, 1921, twenty-seven insufflations being given. Only a partial pneumothorax was obtained. Despite this there was an apparent, temporary improvement with a normal temperature after the eighth insufflation, and a decrease of sputum resulted. The general condition of the patient improved. Hemorrhage did not occur during the last six months of treatment.

By February, 1921, the râles had disappeared. From that time on, the pneumothorax cavity gradually decreased in size, and less and less gas was used. At the same time, the râles returned in the partially collapsed lung. Râles also appeared at the base of the lung (left), and club fingers developed. Treatment was interrupted. The patient died at home in November, 1922.

In the last two cases, the condition was more advanced than in those previously mentioned, only a partial pneumothorax could be obtained, because of the tight band of adhesions and the fact that the condition was a double one.

Tewksbury<sup>74</sup> said that since 1917 he had seen fifteen patients who were treated medically, 25 per cent recovered, the condition became chronic in 5 per cent, and 40 per cent died within a three year period. Surgical methods give a high percentage of recoveries, but convalescence is slow. Of thirty-five patients with acute abscess who were treated by pneumothorax, Tewksbury reported a prompt recovery in twenty-eight cases (80 per cent). In three cases, the abscess ruptured into the pleura, and drainage was instituted through the wall of the chest. Complete cure resulted within a few months. Four patients died. Usually only six or seven treatments were necessary.

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<sup>74</sup> Tewksbury, W. D. Acute Pulmonary Abscess Following Tonsillectomy, Treated with Artificial Pneumothorax, *Ann Clin Med* 4 347, 1925.

In 1912, Koniger<sup>9</sup> reported two cases of bilateral chronic bronchiectasis in which the patients were treated by artificial pneumothorax. After a relatively short time, the treatment did not give satisfactory results. In one case, however, the amount of sputum was reduced from 50 to 60 cc to from 10 to 30 cc, in the other from 180 cc to 20 cc.

Wagner, in a communication to Professor Koniger reported two cases of bronchiectasis. The first case was that of a woman aged 23 who had bronchiectasis of the lower lobe of the left lung following pneumonia and abscess of the lung. Artificial pneumothorax in three injections of 1 liter each was given in six weeks. The sputum was reduced from 70 cc to 30 cc, the patient improved daily and was able to work. Two months after the application of artificial pneumothorax the lung expanded to three fourths of its size.

In the second case, a girl aged 15, had bronchiectasis of the lower lobe of the left lung following pneumonia and empyema. She raised 100 cc of foul sputum a day. Artificial pneumothorax in seven doses of from 400 to 700 cc of nitrogen was given in less than three months. A pleural effusion developed. Four months after the beginning of artificial pneumothorax and three weeks after that there was marked improvement. Three months later, the sputum had disappeared entirely.

In 1912, Lowenhjelm<sup>10</sup> reported the case of a woman aged 30 who had an abscess of the middle lobe of the right lung of six years' duration, which was caused by the aspiration of a capsule of resinol. The patient raised from 350 to 500 cc of foul sputum a day. The sputum contained many elastic fibers, on repeated examination tubercle bacilli were not found. She was given an intensive treatment of colloidal silver intravenously which was followed by great improvement. She married and had a child. In 1911, on account of a recurrence of the old symptoms she was given treatment by artificial pneumothorax.

From Oct. 11, 1911, to Nov. 4, 1911, she received seven injections of nitrogen—250, 500, 400, 300, 500, 800 and 500 cc respectively. Good compression was obtained above and below the abscess which was adherent to the wall of the chest. Adhesions prevented the collapse of the abscess which was the size of a closed fist. The expectoration diminished at first, but after a short time continued as before. She gradually grew worse and dyspnea increased, with loss of strength and rise in temperature.

9 Koniger. Ueber die Technik und Indikation des kunstlichen Pneumothorax. *Therap. Monatsh.* 26: 851, 1912.

10 Lowenhjelm, Carl. Ett fall af kavernbildning i lungan efter lungabscess behandlad med pneumothorax artificialis. *Hygien* 74: 992, 1912.



Heuer and MacCready<sup>81</sup> mentioned five cases in which the patients were treated by artificial pneumothorax after exploratory thoracotomy. Two patients were well for from one to ten or more years, the other three could not be traced, but they had recovered at the time treatment was discontinued.

According to Whittemore,<sup>82</sup> from 10 to 30 per cent of the patients may be expected to be cured by expectant treatment. Artificial pneumothorax may cure a small number, it should be used only in those cases in which the lung and costal pleura are not adherent. It is an excellent means of determining whether or not adhesions are present. Bronchoscopy may cure a limited number of patients if treatment is established early. Surgical measures offer an excellent chance for cure in those cases in which other methods have failed or are unsuitable. In eighty-six of the author's cases, 10 per cent of the patients recovered with expectant treatment. In fifty-two cases in which surgical measures were used, the mortality was 15 per cent.

In 1924, Meyer-Bornecke<sup>83</sup> reported eleven cases in which artificial pneumothorax was used. Three of the patients died, one was discharged unrelieved, one improved and six were cured. Two of the three patients died who had cases that were not suitable for the employment of pneumothorax, as the process was gangrenous. In the second case, pneumothorax was not applied until the day before death. Of the six patients who were cured, four had gangrene, one an abscess of the lung, and the other had a putrid abscess.

In 1925, Winner<sup>84</sup> reported five cases. In the first case, the patient had an abscess of the lower lobe of the left lung following tonsillectomy. There was slight improvement following postural treatment, but as the temperature was intermittent, pneumothorax was started, twelve installations of gas being given. The patient recovered.

In the second case, an abscess developed in the lower lobe of the right lung following appendectomy. The patient had chills and fever. From three to four cups of foul sputum were expectorated daily for one month. Pneumothorax treatment was given for seven weeks, the patient received in all 6,500 cc of gas, and recovered.

In the third case, the patient had an abscess in the middle lobe of the right lung following influenza. He raised a large amount of foul

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81 Heuer and MacCready. Lung Abscess, *Arch Surg* **6** 337 (Jan.) 1923.

82 Whittemore, W. Etiology and Treatment of Nontuberculous Abscess, *Surg Gynec Obst* **38** 461, 1924.

83 Meyer-Bornecke. Ueber die Behandlung von Lungengangrän und Lungenabszess, mit besonderer Berücksichtigung der Pneumothoraxtherapie, *Mitt a d Grenzgeb d Med u Chir* **37** 65, 1923.

84 Winner, P. S. A Study of Twenty-Two Cases of Lung Abscess, *Illinois M J* **47** 267, 1925.

flations was not published, because he was still under treatment at the time the article was published. The lung collapsed to the size of a small hand, with a few bands of adhesions on the front side of the thorax.

The patient was able to do full time work and was almost entirely free from symptoms. If there was too long an interval between the insufflations, the sputum and cough returned.

**Summary.** In a double postpneumonic process with free pleural space, an almost complete pneumothorax was produced in the more involved lung, and as long as insufflations were repeated frequently enough, the sputum was kept in abeyance with good effect. Subsequent results were not known.

In 1912, Brauns<sup>12</sup> reported three cases of bronchiectasis. The first occurred in a woman, aged 27, with the process on one side. Twelve insufflations were given. The patient was cured, although no later reports were given.

The second case was that of a man, aged 41, with a one-sided process. Seventeen insufflations were given. The patient was cured. Later examinations were not made.

The third case was that of a man, aged 40. There were changes in both lungs. He improved after seventeen insufflations and was still being treated at the time the article was published.

In 1913, Penzoldt<sup>13</sup> reported that in one case improvement did not appear until long after pneumothorax. The patient then grew worse owing to a pleural infection. After immediate thoracotomy was performed and extensive treatment of the pleura was given, complete cure resulted. A later report was not given.

Pekanovics<sup>14</sup> gave a brief abstract of one case in which only partial pneumothorax was obtained, owing to pleural adhesions, but temporary improvement was noted in the hemorrhages as well as in the temperature.

In 1913, King and Mills<sup>15</sup> reported unsuccessful treatment of a man with an abscess of the lung and infection of the sphenoidal sinuses. After three injections of nitrogen (500, 600 and 600 cc. respectively) the treatment was discontinued. Improvement was not noted and the patient died two weeks after discharge from the hospital.

In 1913, Izar<sup>16</sup> reported the case of a man, aged 55, with an abscess of the upper lobe of the right lung, who was treated with

12 Brauns, H. *Ztschr. f. Tuberk.* **18**: 549, 1911-1912.

13 Penzoldt. *Verhandl. d. Kongr. inn. Med.* 1913, p. 75.

14 Pekanovics, S. *Budapesti orv. t. g.* 1912, 10: 57. *Internat. J. Tuberc. Forsch.* 1912-1913, p. 74, 75, 77.

15 King and Mills. *Am. J. M. Sc.* 1913, 10: 173, 177.

16 Izar, G. *Un caso di ascesso polmonare con empiema e pneumotorace artificiale.* *Policlinico* **20**: 449, 1913.

cold which was followed by cough. He expectorated mucopurulent sputum which became purulent and gradually increased in amount, until he was spitting about a sputum box full a day. This persisted for some time, and gradually the condition improved, but each time he developed a cold or an infection of the upper respiratory tract, it would be followed by expectoration of quantities of sputum which at times had a foul odor. About a year before this article was written, he had a severe pleuritic pain in the right side of the chest. During these years of frequent invalidism, he gradually lost weight. The sputum was examined many times, but did not show any tubercle bacilli. On admission, there was a dense homogeneous shadow at the base of the right lung, and the physical signs showed consolidation with cavity formation.

His fingers were markedly clubbed, and there was a strong odor to his sputum on admission to the hospital, he did not have fever.

About a month after admission, a bronchoscope was passed down into this cavity, the pus evacuated and iodized oil 40 per cent inserted.

Pneumothorax or artificial collapse of the lung was begun on Nov. 23, 1926. Within six weeks after the collapse was started, he became free from symptoms and has remained free for four and one-half months, the time of the last report.

Since admission, he had gained in weight from 110 to 144 pounds (49.9 to 65.3 Kg.).

abscess was caused by the inhalation of a small bone twenty months previously. She raised from 750 to 800 cc of foul sputum daily. She was treated for nine months, and following the last injection of 1,080 cc of nitrogen, she had a severe coughing spell, during which she expelled a small piece of bone. Seven months after the last injection, the patient was in excellent health, she had only a slight cough and raised only 1 ounce (30 cc) of sputum daily.

In 1914, Nugel<sup>22</sup> reported the case of a youth, aged 17, who had been ill a long time. The left half of the chest was narrower than the right. Nine insufflations were given in two and one-half months and there was complete pneumothorax. Less than four months after the treatment was begun, the patient's general condition was good, there was little sputum and it was not foul. The patient was relatively cured. Later results were not given.

**Summary.** This was an old, principally one-sided process without marked physical signs or adhesions. Complete pneumothorax quickly brought about a cure, but the sputum did not disappear entirely.

In 1914, Jacobaeus<sup>23</sup> reported a case of a man, aged 34, who had been coughing at times for the past fourteen years. During the last four years, there had often been blood in the sputum. Attempts at pneumothorax were ineffectual, and for nine months, insufflations were given anteriorly and a diffuse pneumothorax developed over the upper lobe. The patient had difficulty in expectorating a large amount of sputum. Septic symptoms appeared and the patient died.

**Summary.** This was a one-sided advanced case of double synchia of long standing. Partial pneumothorax brought about collapse of one healthy lobe and sepsis.

Leuret and Aubert<sup>24</sup> reported three cases in which treatment was successful. The first case was that of a man who had an abscess of the middle lobe of the right lung of two years' duration. He raised large quantities of sputum and had had a severe hemorrhage. The second case was that of a boy with an abscess of the middle lobe communicating with a bronchus who also had had a severe hemorrhage.

22 Nugel. Zur Kasuistik des künstlichen Pneumothorax bei Tuberkulose und Bronchiektasien. Inaug. diss. Bonn, 1914.

23 Jacobaeus, H. C. Nord. med. Ark. 1914, nos. 1-4, vol. 47.

24 Leuret and Aubert. Un cas d'abcès du poulmon ou de bronchie dans les bronches guéri par le pneumothorax artificiel. Gaz. heb. de Bordeaux, June, 1914, no. 26, p. 303. Second observation de pneumothorax artificiel. Ibid., June, 1914, no. 26, p. 305. Un cas d'abcès de l'interlobe évacué dans les bronches guéri par le pneumothorax artificiel. Ibid., June, 1914, no. 26, p. 305. med. de Paris 86 71 1915.

off drainage already partially established, resulting in an exacerbation rather than a relief of symptoms. This has been our experience in some cases and has been reported also by others. We also feel that the expulsive action of the cough, which is, after all, the one most important factor in lung drainage, may be hampered in a lung partially immobilized by a pneumothorax.

Our most serious objection, however, is the very real danger that the pleura may be ruptured when this method is employed in abscesses, with a resulting acute septic empyema necessitating immediate operation and under circumstances which render the danger to life exceedingly great. We have had a few such experiences and reports of similar cases occur rather frequently in the literature.

Upon the whole, therefore, we believe that this procedure carries with it too great a risk to warrant its employment as a routine procedure in the treatment of lung abscess at the same time realizing that with a fortunate combination of circumstances, especially in lesions situated near the hilum, brilliant results, as in one of our own cases, may be obtained by its use.

We have consequently employed artificial pneumothorax in only ten cases out of one hundred which we recently gathered together for study and in one of these prompt recovery ensued. In the others it seemed to have little or no effect.

Whittemore<sup>3</sup> has expressed himself repeatedly on this subject, and in his latest publication he said that artificial pneumothorax will cure a limited number of patients, especially if it is instituted early. Little can be accomplished if this is not undertaken until the lung and the costal pleura are adherent, therefore a collapse of the lung must be brought about early, before this takes place. In certain instances in which there are firm adhesions, a partial collapse of the lung may be of temporary benefit. This procedure, by diminishing the distressing cough and the foul odor of the sputum, so that the patient obtains rest and nourishment, may improve the condition of the patient so that operation may be performed. A careful search of the literature has failed to reveal any considerable number of patients cured by this method. Once in a lifetime there is a "freak" case in which the patient has been cured by one injection of air. We have had one such case. The danger of tearing an adhesion, and thereby opening an abscess situated in the periphery of the lung and producing an empyema, should be remembered.

Tewksbury<sup>4</sup> is the most enthusiastic advocate of this method of treatment. In several articles he reported a high percentage of cures.

Lockwood<sup>5</sup> said that artificial pneumothorax should be tried for the small encapsulated abscess not connected with a bronchus, and perhaps for the ordinary long-standing, well localized abscess.

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3 Whittemore, Wyman. *Boston M & S J* **192** 664 (April) 1925

4 Tewksbury, W. D. *Pulmonary Abscess, J A M A* **68** 770 (March 10) 1917, *Pneumothorax in Nontuberculous Lung Abscess, ibid* **70** 293 (Feb 2) 1918

5 Lockwood, A. L. *Lung Abscess, Arch Surg* **6** 314 (Jan) 1923

Matson also reported successful treatment in a case of postpneumonic empyema in which he aspirated the pus and injected nitrogen to maintain the lung in a state of collapse.

In two cases of bronchiectasis, collapse was not possible owing to extensive adhesions. A case of abscess of the lung in a diabetic person and a case of gangrene of the lung is reported in which lasting benefit was not obtained from collapse therapy.

In 1914, Balboni<sup>29</sup> reported a case of abscess of the upper lobe of the right lung and a case of bronchiectasis of the left lung in which the patients were successfully treated by artificial pneumothorax. They were well and free from symptoms one and two years respectively after suspension of treatment.

Balboni also reported the case of a man, aged 50 with an abscess of the lower lobe of the left lung, in which treatment by artificial pneumothorax was attempted because the condition of the patient did not permit a surgical operation. Only a partial pneumothorax was possible as the lower lobe was adherent, and treatment had to be discontinued. There was some symptomatic relief, because further injections caused cardiac distress, severe dyspnea and coughing, treatment was abandoned.

In the case of diffuse bronchiectasis of the right lung with a lesser involvement of the lower lobe of the left lung symptomatic relief was obtained. Ten months after the suspension of the pneumothorax the lower lobe of the right lung was drained surgically by Dr. Waman Whittemore. These are cases 21, 22, 53 and 59 of the series.

In 1914, Zink<sup>30</sup> reported among his 110 cases the following case of bronchiectasis. A boy, aged 9, had been ill for three years with a bronchiectasis in the lower lobe of the left lung and had raised a large quantity of sputum which did not show tubercle bacilli. He was treated from April 1912, to February 1913, during which period his general condition was good, the sputum diminished in quantity but remained fetid. Despite the youthful age of the patient Zink felt that it is questionable whether a cure could be effected by pneumothorax.

In 1915, Wagner<sup>31</sup> reported the case of a man, aged 28, who had bronchiectasis of the lower lobe of the left lung following pneumonia. Three insufflations were given in the course of six weeks. There was marked improvement, the patient being able to do full time work. Ten months after pneumothorax was applied the lung had stretched out to three fourths of its volume. Nothing was known of the later results.

<sup>29</sup> Balboni G. M. Forlanni's Artificial Pneumothorax—A Study. Part I. Parts. Boston M. & S. J. **171** 697 (Nov. 5) 1914. **171** 955 (Dec. 24) 1914. A discussion on abscess of the lung and bronchiectasis. *Tr. Am. Soc. S. C.* **22** 619 1914.

<sup>30</sup> Zink. 110 Fälle von künstlichem Pneumothorax und deren Beobachtungen. *Beitr. z. klin. d. Tuberk.* **28** 155 1914.

<sup>31</sup> Wagner. Diss. Erlang. 1915.

from 3 to 4 ounces of thin, foul pus as if an abscess had ruptured. A roentgenogram taken immediately after the evacuation showed far less density than before, and it was possible to demonstrate many small cavities. In addition, there was a suspicion of a pleuritic effusion.

The child continued to fail, however, and more radical measures were considered. An exploratory puncture was made in the eighth intercostal space chiefly to determine whether an empyema existed. About 1 cc of the same foul pus was found that was being expectorated, but it could not be determined whether it had been obtained from the pleural cavity or from the lung. Immediate

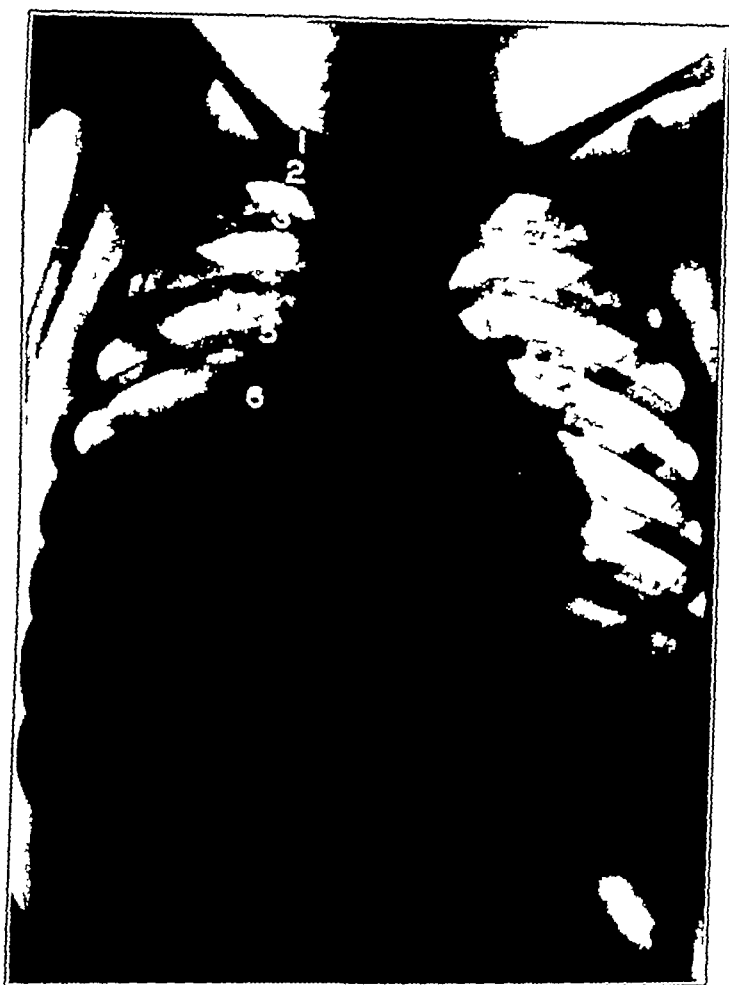


Fig 1—Suppurative involvement of lower right lobe extending to level of sixth rib

operation was advised and carried out the same day. Under local anesthesia, about two inches (5 cm) of the ninth rib was resected in the posterior axillary line. Repeated punctures through the rib bed were negative. Air rushed into the pleural cavity through these punctures, and the attempt to strike pus was abandoned. A small safety-pin was placed against the parietal pleura at the site of the original puncture, to be used as a future guide, and iodoform gauze was then packed into the wound to favor pleural adhesions, the intention being to institute drainage at a later operation. With the exception of marked cyanosis, the child stood the operation well and did not show unusual signs of shock or dyspnea. A roentgenogram was taken at once that showed partial collapse of the

In 1916, Epifano<sup>36</sup> reported the case of a man aged 57 with abscess of the lower lobe of the left lung communicating with a bronchus. He was treated for four months and recovered.

In 1916, Antonucci<sup>37</sup> reported the case of a woman aged 59 with an abscess of the middle lobe of the right lung communicating with a bronchus. The patient was treated for four months. Good collapse was obtained in spite of an adhesion of the upper lobe. The patient was well several months after complete reexpansion of the lung.

Antonucci also made note of a case of pulmonary gangrene following an acute condition resulting from a perforated appendix. In this case artificial pneumothorax acted unfavorably because the collapse obtained interfered with the emptying of the abscess cavity.

Greer<sup>38</sup> reported a case of a boy, aged 5 who had an acute interlobar empyema which was draining through a bronchus. Three injections of nitrogen were given from May to June. The pus entirely disappeared, and four months later, the lung reexpanded. The child was reported in perfect health.

In 1917, Tewksbury<sup>39</sup> reported two cases of abscess of the lung in which the patients were treated by artificial pneumothorax. In 1918, he reported ten cases and in 1919, he gave a final report of fourteen cases, in eleven of which recovery was reported one and two years after the suspension of treatment. He concluded by saying that artificial pneumothorax used early is the most rational and successful treatment for abscess of the lung.

Klinkert<sup>40</sup> reported a case of chronic abscess of the lung of six months' duration, with fever, loss of weight and foul sputum. The patient was given thirteen injections during three months. Three months after the last injection, he was reported well.

In 1918, Simons and Swezy<sup>41</sup> reported a case of acute pulmonary abscess in a woman aged 22, due to secondary invasion of a chronically

36 Epifano G. Un caso di gangrena polmonare guarita col pneumotorace artificiale, *Ann di clin med* 7 25, 1916.

37 Antonucci, C. Un caso di gangrena polmonare acuta e recidivata curata con il pneumotorace artificiale alla Forlanini. *Riv osp* 6 745, 1916.

38 Greer A. E. Interlobar Empyema Treated by Artificial Pneumothorax. *J A M A* 66 1019 (April 1) 1916.

39 Tewksbury W. D. Acute Pulmonary Abscess Treated with Artificial Pneumothorax. Two Cases. *J A M A* 68 770 (March 10) 1917. Treatment of Nontuberculous Lung Abscess with Pneumothorax. Report of Four Cases. *ibid* 70 293 (Feb. 2) 1918. Acute Pulmonary Abscess. Report of Four Cases Treated with Artificial Pneumothorax. *New York M J* 110 820, 1918.

40 Klinkert. Pneumothorax en dorstkwichbehandeling bij pyococcie. *I Jessen Nedel Tidschr v Geneesk* 3 67, 1918.

41 Simons and Swezy. An Acute Pulmonary Abscess Treated with Artificial Pneumothorax. *Am Rev Tuberc* 2 92, 1918.



formed to prove this, and iodized oil 40 per cent was injected into the lower lobe, with the result shown in figure 4. A contracted little lobe with dilated bronchi was outlined. This lobe has remained in the same state and has not given rise to symptoms. The other lobes completely fill the chest, as shown in figure 5, which was taken eight months after operation. The patient has remained well.

#### COMMENT

What does such a case teach? Is it simply one of the freak cases of which Whittemore speaks, or does it point the way to better understanding and treatment in certain well selected cases? We were dealing



Fig. 3.—Pneumothorax on the right side and partial collapse of all lobes one week after operation.

with a pus-soaked lung with a good bronchial outlet, no other method of treatment would have been as effective. As a matter of fact, other methods had been tried and had failed. In other nonrigid parts of the body the soft parts can fall together and help obliterate the suppurative focus, but this is not possible in the rigid chest. The lung is kept expanded by the negative pressure without, and coughing alone has to be relied on to expel the pus. We know that this is not always sufficient, and for this reason postural drainage has been devised and bronchoscopy has been employed to draw out pus that otherwise would be retained. If by the induction of pneumothorax one can add one more factor

course of four months. There was total collapse and the sputum disappeared. Examination two months later showed that the lung was almost entirely reexpanded. Ten months after ceasing treatment the patient was able to do full time work.

**Summary** This was a one-sided, relatively fresh postpneumonic process without severe local symptoms.

The second case was that of a man, aged 43, who had been ill for two and one-half years. He had had foul sputum for nine months. Ten insufflations were given in the course of five months, almost entire collapse of the lung resulted. Eight months later the fever had disappeared and the patient felt well.

**Summary** This was a relatively fresh one-sided moderately severe process. Almost complete collapse brought about cure without disappearance of the sputum.

The third case was that of a man, aged 39, who had had pneumonia of the lower lobe of the left lung four years previously. The sputum had gradually increased. Pneumothorax was maintained for four months and complete collapse of the lung resulted.

**Summary** This was a moderately advanced, one-sided postpneumonic process, and treatment caused little improvement.

The fourth case was that of a woman, aged 27, who eight years previously, had had pleural pneumonia in the lower lobe of the right lung, with cough, sputum and at times a rise in temperature. She had had a hemorrhage a year and a half previously. Complete pneumothorax was obtained after this process had been maintained for six months.

**Summary** This was an old one-sided process with moderately severe clinical symptoms. Because of the long duration of the illness and the fixed bronchial wall only slight improvement was obtained.

The fifth case was that of a man, aged 32, who two years before pneumothorax was begun had had pneumonia. Three months later hemorrhage occurred and the amount of sputum increased. Eight insufflations were given in the course of three and one-half months. Complete pneumothorax resulted and the sputum disappeared. Ten months later the patient felt well and did not have fever.

**Summary** The patient had a relatively fresh one-sided moderately severe process. Complete collapse of the lung after a very short time of treatment resulted in complete cure.

In a sixth case only small partial pneumothorax was obtained because of strong and diffuse adhesions. Treatment was continued and the results were negative.

In another case many unsuccessful attempts were made to get the pleural space could not be found. The results were negative.

The two important factors necessary for the success of this method of treatment seem to be a free bronchial outlet and a nonadherent lung. This means early cases. Another important point is that the operation should be performed under local anesthesia in order to allow the patient to expectorate during the operation, the likelihood of pus flowing over into other bronchi is thus diminished, and there is no more danger than during ordinary postural drainage.

Treatment by collapse of the lung has a practical counterpart in many of the cases of abscess of the lung which perforate spontaneously

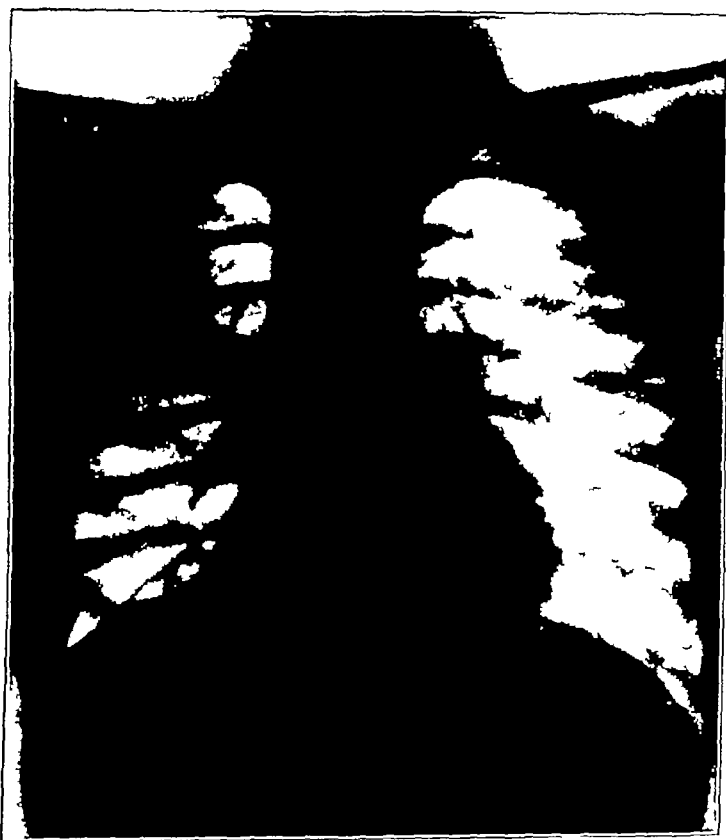


Fig. 5—Final result eight months after operation. The collapsed lower lobe seen close to mediastinum does not give rise to symptoms. Other lobes completely fill the thorax.

into the pleura and form an empyema. As is well known, simple drainage of the empyema will usually result in a cure of the underlying abscess of the lung. The curative mechanism in these cases consists of two factors: first, the drainage of the abscess, second, the resulting collapse of the affected lobe or portion of a lobe. It is even probable that actual compression of the lung may result from the combination of air and pus. After drainage of the empyema, the adhesions of the lung to the wall of the chest will help further in the obliteration by drawing the ribs inward. In this connection it may be

lung. There was much sputum and vomiting. Partial pneumothorax was obtained. Treatment was continued, the sputum decreased slightly, but increased when the treatment was interrupted.

The tenth case was that of a young girl in whom pneumothorax was maintained for three years on account of bronchiectasis of the lower lobe of the right lung. The patient became able to work full time. The foul sputum disappeared. Treatment was discontinued but after a few weeks, all the symptoms reappeared. Pneumothorax was again instituted, and the patient was well.

Goldberg and Bresenthal<sup>47</sup> reported three cases.

The first case was that of a man, aged 21, who had an abscess of the middle lobe of the right lung and who was treated for six and one-half weeks. Three injections of 1,000 cc each were given.

The third case was that of a woman, aged 30, who had an abscess in the upper lobe of the left lung with the cavity having a fluid level. She received two injections of 700 and 400 cc in three days.

The third case was that of a man, aged 49, who had an abscess in the upper lobe of the right lung, the cavity having a fluid level. Seven injections were given. All these patients were reported well.

Martin and Caldwell<sup>48</sup> reported a case of a woman, aged 27, who developed an abscess of the upper lobe of the right lung following the extraction of teeth. She was given a few treatments and reported cured. Details of the treatment were not given.

In 1920, Landolt<sup>49</sup> reported a case of a man, aged 22, who had had pneumonia at 5 years of age. For the last four years he had had a cough and had expectorated considerable sputum. For one and one-half years he had lost weight and had night sweats. Pneumothorax therapy was given, the duration is not known. Partial pneumothorax resulted. There was marked improvement for at least a few months.

Wessler<sup>50</sup> mentioned two cases in which artificial pneumothorax was performed, not only was there an extension of the disease, but both patients died shortly after the last insufflation. Details of treatment or of the roentgen-ray examination were not given. He concluded that the procedure was without value and might be harmful. A detailed history of the case was lacking and the cause of death was not given.

47 Goldberg B. and Bresenthal M. The Treatment of Abscesses of the Lung by Artificial Pneumothorax. A Report on Three Cases. *Ann. Surg.* 1919, 70: 169. 1919.

48 Martin C. F. and Caldwell D. M. Lung Abscess Cured by Artificial Pneumothorax Following Extraction of the Teeth. *Ann. Surg.* 1920, 71: 451. 1920.

49 Landolt M. *Pravica-Peier* 1920, 12: 1-4.

50 Wessler Harry. *Supplement* 1920, 27: 1-2.

# RELATION OF BRONCHOPULMONARY SUPPURATION TO EMPYEMA \*

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The term bronchopulmonary suppuration is a broad one and is purposely employed to indicate suppuration within the bronchi and pulmonary parenchyma. There are three chief varieties of this general lesion: (1) the suppuration which follows the breaking down of an ordinary pneumonic process, (2) suppurative metastatic lesions during the course of a general infection, and (3) suppuration which originates within the bronchial tree (*a*) as a surface infection of the bronchial mucosa, (*b*) as retention suppuration due to obstruction by a foreign body, a tumor or a stricture or (*c*) as combinations of retention and infection. Cases of tuberculosis or actinomycosis are not included.

During the past five years, eighty-eight patients with empyema were treated in the service at Mount Sinai Hospital. Approximately 25 per cent of these cases were complicated by some form of bronchopulmonary suppuration. In practically all, the clinical course seemed to indicate that the empyema was secondary to the intrapulmonary lesion. Several of the cases occurred during a general infection, and it seems equally possible that the empyema and the pulmonary abscess were independent lesions. Most of the other cases followed pneumonia. Most of these undoubtedly belong in that large group of parapneumonic or metapneumonic empyemas which, according to the suggestion first made by Rosenbach, result from the perforation into the pleural cavity of superficial foci of liquefaction in an area of pneumonic consolidation. During the World War, the surgeons in the army were able to demonstrate cases in which the sequence was present. I have seen this condition myself a number of times on the operating table and also in postmortem specimens. Cases of this kind undoubtedly form a much larger group than one would suppose.

In clinical practice the forms of bronchopulmonary suppuration which originate within the bronchial tree are most commonly associated with obstruction by either a foreign body or a tumor. For reasons which will be described presently, I have never seen an empyema complicate this form of bronchopulmonary suppuration. Nevertheless, secondary changes occur in the structure of the bronchial tree, and bronchiectatic dilatation was found in two of the cases of this series at postmortem examination.

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\* From the Mount Sinai Hospital

with four injections of nitrogen within twelve days with marked improvement in all the symptoms. The patient recovered.

Glendening<sup>55</sup> mentioned treatment by pneumothorax of one patient with abscess of the lung but he did not state the results. In a case of bronchiectasis this treatment was used—improvement but not complete cure, resulted.

Johnston<sup>56</sup> reported the cure of a patient with an abscess of the lower lobe of the left lung following artificial pneumothorax, the abscess was due to aspiration of a piece of bone following operation on the antrum.

In 1914, Cantani and Arena<sup>57</sup> reported a case of abscess of the lower lobe of the left lung in a man, aged 35. He was treated successfully for three months. He developed a pleural effusion which was aspirated and replaced by nitrogen. The patient was free from pulmonary symptoms six months later.

Rondano<sup>58</sup> reported a case of a man with an abscess of the middle lobe of the right lung communicating with a bronchus. He was treated for three months by artificial pneumothorax, complete collapse was maintained, and eight months later the patient was in good general health and free from symptoms.

Denechau<sup>59</sup> reported two cases of pulmonary gangrene in which the patients were successfully treated with artificial pneumothorax and antigangrenous serum. The antigangrenous serum caused improvement—loss of odor and diminution of sputum. Soon the action of the serum diminished and complete recovery took place only when pneumothorax was performed.

Denechau and others reported two other cases in which the patient were treated the same way with excellent results.

55. Glendening, L. The Use of Artificial Pneumothorax in Tuberculosis, Hemothorax, Bronchiectasis, and in Advanced Pulmonary Tuberculosis. *New West J. M. & S.* **29** 17, 1921.

56. Johnston, C. H. Artificial Pneumothorax in Tuberculosis, Abscess of the Lung, Pulmonary Abscess and Pulmonary Hemorrhage. *J. Michigan M. S.* **29** 5 (Nov.) 1921.

57. Cantani and Arena, H. Pneumotorace artificiale nel trattamento di altri affezioni dell'apparato respiratorio. *ed.* 1921, p. 81.

58. Rondano, I. Gangrena polmonare curata col p. a. *Riv. crit. di clin. med.* **22** 97, 1921.

59. Denechau, D. Deux cas de gangrene pulmonaire traités par le pneumothorax artificiel et le sérum antigangreneux. *Bull. Acad. d'Anvers* **25** 211, 1921. Denechau, D. Les gangrenes pulmonaires traitées par le pneumothorax artificiel et le sérum antigangreneux. *Ann. des Mal. Respir.* **1** 1, 1921. Denechau, D. Les gangrenes pulmonaires traitées par le pneumothorax artificiel et le sérum antigangreneux. *Bull. Acad. d'Anvers* **25** 211, 1921. Denechau, D. Les gangrenes pulmonaires traitées par le pneumothorax artificiel et le sérum antigangreneux. *Bull. Acad. d'Anvers* **25** 211, 1921. Denechau, D. Les gangrenes pulmonaires traitées par le pneumothorax artificiel et le sérum antigangreneux. *Bull. Acad. d'Anvers* **25** 211, 1921.

occasions A patient would be operated on for empyema which apparently did not have any bronchopulmonary communication As the patient was subsequently watched, one noted that the primary pneumonia was being overcome Then the presence of the bronchopulmonary communication would be discovered, frequently through the "gassing" of the patient during an irrigation of the empyema cavity with a surgical solution of chlorinated soda, when previous irrigations had not caused discomfort Undoubtedly, the complete resorption of the pulmonic exudate had much to do with the "opening up" of the bronchopulmonary fistula

In this series of cases of empyema, the pulmonary suppurations occurred in the form of soft abscesses, and they were frequently multiple This seems to have an important relation to the subsequent formation of bronchopulmonary fistulas In this variety there is a comparatively acute abscess formation, with soft, nondemarcating walls, it is commonly accompanied by few if any physical signs and roentgenologic evidence, and is apt to cause acute perforations between the nonadherent visceral and parietal pleurae The outstanding histologic fact is that these abscesses do not have a surrounding area of induration Many of these cases of empyema take the clinical form of a hyperacute pyopneumothorax, some form of bronchopulmonary fistula usually develops

In this series, there was only one case in which an abscess existed which resembled the hard indurated form so commonly seen after a variety of other causes as, for example, after tonsillectomy It appears that the character of the pathologic process in this form of abscess is not conducive to a comparatively sudden infection of the pleura which would produce a pleural effusion and empyema, and the large amount of indurated infiltration around the abscess cavity does not permit any sudden rupture into the pleural space Anatomically, the lesion consists of a central cavity containing foul-smelling, brownish-red grumous pus in which a multitude of aerobic and, especially, anaerobic organisms flourish, a limiting granulation membrane of firm consistence, and a wide surrounding area of induration merging into pulmonary tissue in which fibrosis, secondary bronchiectatic dilatation and atrophy predominate The lesion may be single or multiple, and an advanced grade of suppurative bronchitis is associated with it An adhesive pleuritis is almost the rule and is usually limited to the area of lung involved The process begins with obstruction of the bronchus and secondary infection Of necessity, from the beginning a communication is present with one or more fairly large sized bronchi, more or less free drainage of the abscess into the bronchial tree is constantly present from the inception of the pathologic process

This form of pulmonary suppuration practically never perforates into the pleural cavity The pathologic process rarely enlarges progressively





purative process in the midst of the lung tissue. In the cases of empyema and abscess of the lung, the communication is frequently multiple, it is usually direct and extends almost always into one or more fair-sized bronchi of the second or third order, the usually profuse and foul sputum, present before operation, resembles in all particulars the pus of the abscess and of the empyema, but it immediately disappears following the adequate drainage of the empyema and of the pulmonary focus and reappears directly after interference with the drainage. Healing is tedious and prolonged, and often the bronchial fistula is an almost insurmountable obstacle to the closure of the sinus of the wall of the chest until, and perhaps even after, a radical operation is performed. In the cases of metapneumonic empyema, a communication with the larger bronchi is not demonstrable. The demonstrable fistulas are short and narrow and communicate with the pulmonary parenchyma and with the smallest or terminal bronchi. The amount of infiltration around the sinus tract is at a minimum, and the tissues are soft and pliable and have a tendency to fall together, facilities for healing are most favorable in these cases. As a rule, these communications heal spontaneously and close quickly, and they rarely cause any extraordinary prolongation of the cicatrization of the wound. Characteristically, the amount and physical appearances of the sputum are independent of the contents of the empyema cavity, it does not resemble the discharges from the wound, and depends for its production on an associated bronchitis or on the liquefaction of the pneumonic exudate which antedated the empyema.

In the cases of metapneumonic empyema in this series, a marked improvement has been demonstrated in the results of treatment as compared with the results I published in 1915. The mortality rate in general hospitals, including all kinds of cases, has fallen from 28 per cent to approximately 10 per cent. In this series of eighty-eight cases of empyema, the wounds of all but three of the patients who recovered healed completely after the primary operation and remained healed. With few exceptions the postoperative convalescence was uneventful. The great care which was taken in dressing the operative wounds and in the general treatment of the patient was thought to be responsible for the good results. All of the three patients in whom secondary operations were necessary recovered, and the wounds eventually healed.

Experiences at the Mount Sinai Hospital have led us to the belief that in cases of empyema associated with some form of bronchopulmonary suppuration healing eventually takes place in a large proportion of the patients who do not succumb to the effects of the primary illness or to some complication. Naturally, the mortality of these two factors is large. Healing will occur even when a bronchopulmonary fistula is present, if there are no other factors to interfere with the healing. Failure to heal depends on two all powerful causes (1) the

Tillman<sup>73</sup> reported a number of cases. The first was that of a young man with a unilateral moderately severe bronchiectasis who was treated for more than six years with artificial pneumothorax. The slightly purulent secretion never disappeared entirely. How clearly the process was completely healed was shown by the quick recovery from the rather severe infection at the time the treatment was being stopped. The treatment did not have any detrimental effects on the heart and did not prohibit the later reexpansion of the lung. It must be mentioned that the fact that the patient recognized his own condition made possible the long protracted treatment.

The second case was that of a man, aged 24, who had pneumonia on the right side during the influenza epidemic in 1918. He was ill for five months, several of which were spent in bed. There had been sputum and slight dyspnea since September, 1921. Marked hemorrhage occurred in February, 1922, after fever and increased cough. In March, 1922, there was no definite dullness. By Aug. 3, 1922, the patient had had nine insufflations, and treatment was still being given. A quick, good, but not complete collapse of the lung was obtained. The sputum ceased, and after eight months the condition of the patient was good. He was able to attend to work.

**Summary.** This was a one-sided, anatomically moderately severe, subjectively light, case despite a duration of at least three years. The lung collapsed easily, but not completely; the sputum disappeared, and the patient was reported well.

The third case was that of a man, aged 20, who had had pneumonia at 8 years of age. He had been in bed four weeks. In 1918 he expectorated a teaspoonful of blood while coughing. For the next four winters, he had had long periods of coughing, but expectorated little sputum. In April 1922, the condition recurred, accompanied by high fever and considerable purulent sputum for several days. In August 1922 a marked hemorrhage occurred, followed by several hemorrhages later. In May 1923 the general condition of the patient was good. An attempt to apply pneumothorax was made, but it revealed a definitely thickened pleura. There was no air over the upper lobe, but a definite gas shadow could be seen over the lower lobe.

**Summary.** This was an old, double, anatomically moderate pneumonia. Pneumothorax was prevented by strong fibrous adhesions to the pronounced lobe.

The fourth case was that of a youth, aged 19, who had pneumonia in March 1917. In August 1918 he had had a severe attack, with several small hemorrhages. He had been in bed for several months.

<sup>73</sup> Tillman, John. *Uterine and Vaginal Infections*. Philadelphia: Proctor and Kuster, 1922. p. 59.

Both of these factors seem of equal importance, and the interaction of the two are sometimes sufficient to produce a vicious circle. The control of the infection is the first object, for this purpose, time is a great aid. Some of the fistulas which at first look impossible will eventually close when the infection is spontaneously controlled. The stubborn cases are due to forms of suppurative bronchitis in which an interstitial form of inflammation has occurred together with destruction of the superficial mucosa and with secondary bronchiectasis. In a few of the cases, injections of bismuth have seemed to me to be of some aid. In the most stubborn cases, it becomes necessary to destroy that part of the lung in which the sinus tract exists and in which the bronchi are the seat of this suppurative inflammation. The best way to do this is to destroy these areas progressively with the cautery at repeated sittings. Unless this infection can be controlled, practically nothing can be done toward securing a closure of the empyema cavity.

On a previous occasion, I discussed the various forms of empyema cavity which can exist with a bronchopulmonary fistula. It was pointed out at that time that unless the empyema cavity can be obliterated, the lung remains tied down and no expansion of its substance takes place, without this expansion a fistula of any size will not close. When the bronchopulmonary fistula is present with any except the smallest of empyema cavities, determined efforts must be made to secure the necessary obliteration, otherwise closure of the fistula and healing of the empyema will not occur. Time and meticulous surgical care of the wound produce astounding results. In the cases of large fistulas and large empyema cavities, it is necessary to liberate the lung mechanically (1) by freeing it at the periphery of the empyema cavity, (2) by cross hatching the granulation membrane covering the lung or (3) by both of these methods. If the lung can be brought up to the wall of the chest by these means, much is accomplished, if not, it becomes necessary to collapse the wall in order to approximate it to the lung and so secure obliteration of the cavity. I have found that the necessity for these radical measures has decreased progressively.

The final healing of any resultant fistula depends on the possibility of securing a comparatively uninfected condition of the sinus tract and the communicating portion of the pulmonary parenchyma with its contained bronchi. Unless this can be secured, the sinus tract will remain open indefinitely. The greatest obstacle to this is any bronchiectatic condition. Luckily, given sufficient time—and this seems to be an all important factor with these conditions of the chest—the sinus will gradually close.

There have been two experiences in this series in which these difficulties were encountered



There were twelve cases in this series in which the bronchopulmonary suppuration had progressed so far in the healing stage as to leave only a fistulous tract. Ten of these patients recovered. The conditions in these cases were as follows: empyema originating from a pneumonic process, four cases; recurrent empyemas with fistula, two cases; infection of the upper respiratory tract including otitis media (grippe infection), two cases; and general infection (sepsis), two cases. Two of the patients died: one as a result of a spreading retropharyngeal abscess to which the empyema was probably secondary; the other, from mediastinitis and pericarditis.

sputum. The fingers were clubbed. Treatment by pneumothorax was given for eleven weeks, 5,900 cc. of gas being injected. During treatment a slight effusion developed. The patient recovered.

The fourth case was that of a patient who had an abscess in the upper lobe of the right lung following tonsillectomy. A large amount of foul sputum was expectorated. The patient had chills and fever and lost weight. Pneumothorax failed on account of an adherent pleura. The patient did not improve.

The fifth case was that of a patient who had a chronic abscess of the left lung adjacent to the heart of eleven years' duration following pneumonia. A large amount of foul sputum was expectorated. The fingers were clubbed. There were frequent acute exacerbations. Artificial pneumothorax was caused, the patient receiving a total of 3,400 cc. of gas with marked improvement. He is still under treatment.

In 1927 Jacobsen<sup>85</sup> reported three cases of acute pulmonary abscess in which the patients were successfully treated by pneumothorax communicating with a bronchus.

The first case was that of a man, aged 44, who had an abscess of the upper lobe of the right lung of six weeks' duration due to the aspiration of food during a vomiting spell. The sputum was purulent, fever and night sweats developed. The patient was treated expectantly for two weeks, but as he was beginning to raise more foul sputum, pneumothorax was induced and kept up for five weeks. Complete recovery was accomplished.

The second case was that of a man, aged 37, who following an acute respiratory infection had an abscess of eight weeks' duration in the upper lobe of the left lung communicating with a bronchus. The sputum separated into three layers. There were no elastic fibers. Tubercle bacilli were not found. Expectant treatment was given for two weeks, then pneumothorax was induced and maintained for nine months. The patient recovered.

The third case was that of a man, aged 47, who, following acute respiratory infection had an abscess of the upper lobe of the right lung communicating with a bronchus of four weeks' duration. He raised a cupful of foul, purulent, coffee-colored sputum which separated into three layers and contained bacteria of different kinds. Tuberculosis did not occur. Pneumothorax was induced and maintained for four months. He made a complete recovery.

Pettingill<sup>86</sup> reported the following case. A man, aged 38, while working in the mill in Haverhill in February, 1919, developed a severe

<sup>85</sup> Jacobsen, H. C. Some Cases of Acute Pulmonary Abscess Treated by Pneumothorax, *Acta med. Scandinav.* **65**: 697, 1927.

<sup>86</sup> Personal communication to Dr. Gerardo M. Balboni by Dr. Olin S. Pettingill of Essex County Sanatorium, Middletown, Mass.

tion incidental to the pneumothorax which results. Death occurs, not from the disease per se, but from untimely and careless interference by the medical or surgical attendant.

The febrile state of the patient, the elevation of temperature, rapidity of the pulse and respiratory rate, the degree of dyspnea and the toxic condition of the patient generally indicate treatment by aspiration first, and by some type of drainage subsequently.

It is difficult to lay down hard and fast rules for the treatment in so variable a type of disease as acute empyema. The routine procedure employed by me for the past ten years has been as follows, the operator being guided by the patient's condition.

1 Aspiration is performed in the early stage of the disease. If the fluid is thick, air replacement may be employed to hasten the flow of the fluid through the needle.

2 When the patient is not improving, closed drainage is established by the catheter and cannula method, inserted through a dependent interspace and led off to a Winchester half full of water, which is suspended under the bed.

If the fluid is thick, a second catheter may be inserted in the highest space adjacent to the cavity, and the cavity will be irrigated through the upper catheter while it empties through the lower one.

As the tract about the catheter enlarges, a larger tube is inserted, and if the temperature is maintained and the cavity is not reducing appreciably, two or three small Carrel tubes are inserted through the opening and carried on pliable lead sounds to the upper portions of the cavity and irrigation with surgical solution of chlorinated soda is (Dakin's solution) begun.

Forced blowing exercises every hour by the use of large Wolfe bottles are encouraged.

3 If the patient is still not doing as well as is expected the tract of the catheter opening is excised, the incision is extended either way and the thorax is widely opened in the interspace. The cavity is explored with a lighted retractor (Adson's brain retractor), adhesions severed, fibrinous deposits cleared out manually and all encysted or nondependent cavities rendered dependent. Carrel tubes on lead carriers are inserted and irrigation with a surgical solution of chlorinated soda is carried out, every two and a half hours.

4 Should there be any difficulty in gaining and maintaining easy access to the cavity through an interspace, we do not hesitate to resect a rib, widely, being careful to have our opening at the lowest portion of the cavity. Occasionally, after first opening the chest in the interspace and finding that the incision is not dependent, it is necessary to insert the hand and make an opening in a lower space directly on the fingers inserted through the chest. In such an instance, the upper incision is usually closed completely, and the lower opening is maintained.

During the acute stage, patients are placed on forced feeding with highly nourishing foods. Alkalis and dextrose are given by mouth, and small transfusions of blood of from 300 to 500 cc are given and repeated as often as necessary if the patient does not rapidly overcome the toxemia.

Local anesthesia or modified paravertebral anesthesia, if necessary, associated with gas and oxygen analgesia, or better, ethylene analgesia is employed for all operative measures during the acute stage of the disease.

ACUTE PULMONARY SUPPURATION  
SELECTIVE ACTION OF ARTIFICIAL PNEUMOTHORAX  
IN THE TREATMENT OF THIS DISEASE

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On the various methods of treatment advocated in cases of acute nontuberculous intrapulmonary suppuration the induction of artificial pneumothorax has received scant attention. Many writers do not mention it and others vary from unqualified recommendation to condemnation of the method.

Kuttner<sup>1</sup> for instance emphatically condemns Jorlanni's method of artificial pneumothorax in the treatment of abscess of the lung by saying that he believes the spontaneous cure is favored by coughing and expectorating and that pneumothorax prevents this and favors the stagnation of pus. As a result there is great danger of pus flowing over into other bronchi leading to the formation of fresh foci of bronchopneumonia and multiple abscesses.

In 1924 Lambert and Miller,<sup>2</sup> in an analysis of sixty cases of abscess of the lung stated that their experience with the method of artificial pneumothorax had been limited as they had used it on only seven patients none of whom improved and two of whom died. In a more recent analysis of 100 cases by the same authors the following opinions are expressed:

We have employed this method in some cases but tentatively, in order to have actual experience as a basis of judgment rather than with great confidence in it as a rational procedure. The reason for this somewhat experimental method of approach is found in our conception of the radically different objects to be attained in pulmonary tuberculosis as opposed to abscess of the lung. In tuberculosis rest and immobilization of the lung appears to us to be the prime consideration and for this often partial pneumothorax without any actual compression of the lung is adequate.

In abscess drainage is the desired object, and by artificial pneumothorax this can only be facilitated by pressure properly applied upon the right point and in the right direction. We do not feel that this can be accurately gauged in artificial pneumothorax. Moreover it sometimes happens that the air introduced works around into the pleural space near the mediastinum and may actually cut

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1 Kuttner in Bier, Braun and Kummel. Chirurgische Operationslehrer, Leipzig, J. A. Barth 1923.

2 Lambert and Miller. Abscess of Lung Arch Surg 8 446 (Jan.) 1924.  
Lambert. New York State J. Med 27 47 1927.



closure by muscle or skin flap, limited resection of the wall or some allied simple method is preferred because of the saving in time to the patient.

In patients with larger cavities, there is a diminution in the air-bearing capacity of the lungs, and every effort should be made to reexpand the collapsed lung, with a view to restoring the normal vital capacity.

While the apt surgical dictum "*ubi pus, evacua*" does not always apply to patients with acute empyema, it does apply to those in the chronic stage of the disease. Before any extensive operative intervention is undertaken, the cavity should be thoroughly irrigated with surgical solution of chlorinated soda until the lung no longer expands and the discharge is as nearly sterile as possible. Then decortication is planned, if necessary, associated with a partial resection of the bony wall of the chest and thickened parietal pleurae covering the cavity. Lloyd,<sup>9</sup> I believe, was the first to undertake decortication in this country. Fowler<sup>10</sup> described his method of decortication in 1893. Decortication of the visceral pleura properly performed, when followed by complete expansion of the lung, is one of the most satisfactory operations in modern surgery. Unfortunately, in inexperienced hands, or in the hands of the surgeon who only occasionally undertakes such a procedure, the operation is difficult, it is fraught with dangerous possibilities and sequelae recognized only by those who have carried out the operation many times and who have had the intimate after-care of such patients. In addition, it has been our experience that one cannot foretell how completely the lung will expand following decortication. The duration of chronic empyema seems to bear little relation to the ability of the lung to expand. We believe that the degree of expansion depends on the nature of the inflammatory process that originally existed in the lung tissue adjacent to the cavity. For some years, we have as a policy excised a small nodule of the lung when expansion at operation has been limited, and in every instance we have found that various degrees of fibrosis exist which prevent expansion of the lung tissue itself. Care must be taken when this section is made. The cautery is applied to the surface to sterilize it as in autopsy work—the small section is excised with a knife and oversewed, and a small pedicle of fascia is tied over the area of suture. Fowler's patient, a woman, aged 35, had had the cavity for ten years. Expansion was complete in this case. We have obtained complete expansion in a patient whose cavity had existed sixteen years, and two-thirds expansion in a cavity of twenty-one years' standing, but we have repeatedly had less than 50 per cent of expansion in cavities that have been present less than one year. I am personally convinced that the tissue of the lung undergoes a repair process as time goes on, with

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9 Lloyd. Personal communication.

10 Fowler, G. R. M. Rec., Dec. 30, 1893, p. 838.



tions within the thorax, and to allow the wall to collapse partially at least to meet the expanding lung

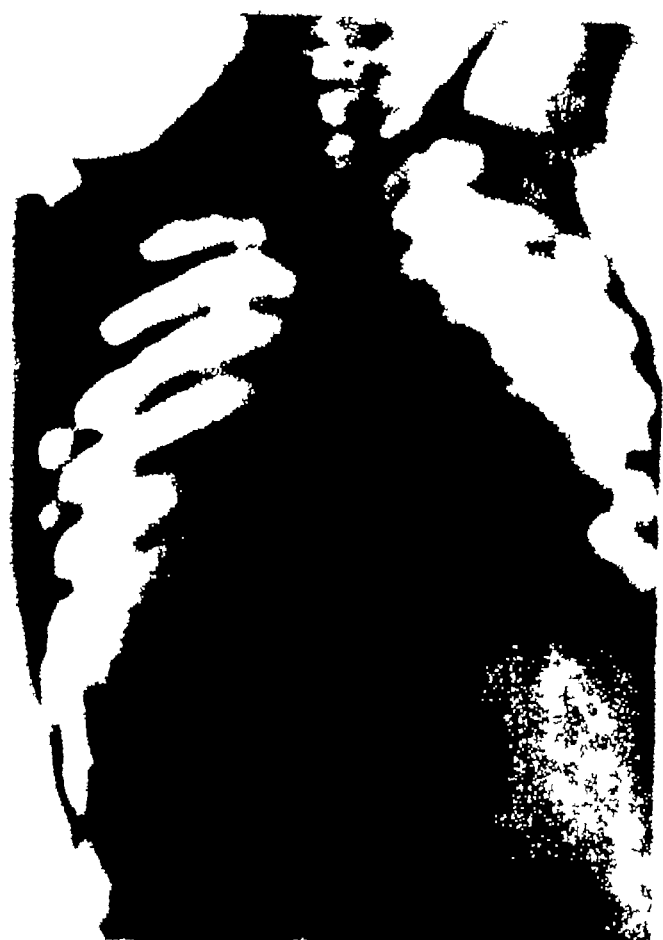
Such procedures as the modified operations of Estlander and Schede are still necessary. The operation of Wilms, i.e., resection of a one-half inch segment of several ribs at their angles posteriorly, and at the costochondral juncture anteriorly, while not commonly employed, is of value in those patients in whom one lung is practically totally collapsed. In all osteoplastic operations, the procedure must be planned so as to allow sufficient shrinkage of what might be described as the roof of the cavity, so that every portion of it comes in direct contact with visceral surface of the underlying and expanding lung. Care should be taken to remove one rib too many rather than one too few. For that purpose, we remove the rib above and below the cavity throughout the length or width of it, according to the position. In most instances we excise the thickened parietal pleura intact with the ribs, so that finally muscle tissue comes in contact with visceral pleura. In removing the roof of the cavity, the skin and muscle flap is turned back intact down to the ribs, the ribs themselves are not stripped of their periosteum, except to allow sufficient space to sever them with the bone forceps, and the upper and lower incisions through the roof pass through the intercostal muscles rather than through the stripped periosteum of the ribs. Parietal decortication itself cannot be too strongly condemned because of grave primary and secondary hemorrhage from intercostal vessels.

Operations designed by Korte, Hellstrom and others of the European school to remove portions of the scapula should not be encouraged. There are a small percentage of patients, however, in whom some of the lower half of the scapula must be removed. This should be done subperiosteally, and there must be no interference with the muscles and nerves. Pediculated muscle and skin flap operations are extremely valuable and must be adapted in some form to most cases. The divided U-shaped flap as suggested by Robinson is most valuable in peculiarly shaped and placed cavities. In a small percentage of cavities placed high anteriorly and directly in the upper portion of the axilla, we have been obliged to unroof the cavity entirely and to expose it completely, in all but one patient we have managed to cover the exposed pleura with skin at once or gradually, either by encouraging the skin edges to granulate in by the use of balsam of Peru or Ochsner's method of using adhesive tape or by skin graft.

We have had little success with the use of bismuth paste, and we rarely employ it. I have so much respect for the work of Emile Beck<sup>15</sup> that I would not condemn its use, but credit our failure to cure even small cavities with it to improper or injudicious use of it.

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15 Beck, E. M. Toxic Effects From Bismuth Subnitrate, J. A. M. A. 52:14 (Jan. 2) 1909.



presented by Dr Santee<sup>11</sup> at a meeting of the New York Surgical Society in which undoubted massive collapse of the lungs without bronchial obstruction was found at autopsy

Dr Eggers speaks of his case as illustrating the selective action of pneumothorax. The actual mechanics of the so-called selective action of pneumothorax is splendidly and convincingly illustrated in an article by Bendove<sup>17</sup>. Anybody who can study his pictures and not be absolutely convinced concerning the way that mechanism acts must be hard to convince.

Dr Eggers said that there is less circulation in a collapsed lung than in an expanded lung. I believe that is not the result obtained by the physiologists. In a collapsed lung, such as results when there is air in the chest but the lung is not compressed, when there is no positive pressure of the pneumatic type but the pressure is normal, it has been stated (Yates<sup>18</sup>) that there is an increase instead of a decrease in the circulation in the vessels in the lung.

I think Dr Yates has made use of this principle as a part of his ingenious method in the treatment of patients with tuberculosis by crushing the phrenic nerve to produce temporary paralysis.

Dr Pickhardt's paper greatly interested me and it showed how observations made at roentgen-ray examination and clinical signs are not always similar.

He demonstrated a normal chest in which first-class diagnosticians had stated that pneumonia was present. I will not try to make an explanation. I only say that it is necessary to have the clinical picture of the case and then to match up the conditions shown by the roentgen-ray examination the best way possible. One may not be able to read the roentgenograms correctly, but the appearances cannot be contradicted.

The case of Anna Rosta was one that I shall not forget. The picture looked like a massive collapse, in fact I believe that the condition was a massive collapse. The heart had been pulled entirely into the affected side.

The traumatism probably had something to do with the abscess. I think Dr Pickhardt has done a good thing in showing us what I have always believed, that so-called unresolved pneumonia is more apt to require surgical treatment than medical.

DR HUGH AUCHINCLOSS, New York. Dr Pickhardt brought out what has become more and more evident to all of us, namely, that unresolved pneumonia is a rarity, and that most cases in which that diagnosis is made are sooner or later shown to be cases of a different condition.

As regards the paths of extension of infection to the lungs and pleura, it is extremely interesting to hear of the enormous number of tonsillectomies that have been performed without the formation of an abscess of the lung.

It seems unwise to confine the path of extension by any one route. It seems to me to be unwise to assume that aspiration is always responsible for extension or that emboli are always responsible. Another route, which seems perhaps to be most important, namely, that route along which the lymphatic stream flows, really is the architectural scaffolding of the lungs, and of course, the blood and lymph vessels are in this same scaffolding. The extension of

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16 Santee. *Ann Surg* 85 608 (April) 1927.

17 Bendove. The Mechanism of Localization of Gas in the Pleural Cavity and Its Clinical Application in Pneumothorax Therapy, *Arch Surg* 13 369 (Sept) 1926.

18 Cloetta, quoted by Yates. Surgery in Pulmonary Tuberculosis, *Arch Surg* 14 372 (Jan) 1927.



Embolism is the cause of abscess of the lung in many cases, but the majority of cases of abscess of the lung are due to aspiration. At least I and many others believe that this is true.

It was instructive to hear Dr. Crowe speak of the experiments that had produced abscess of the lung in dogs by aspiration after the pus had been heated. I understood him to say that microbes act differently when suspended in a cool fluid.

It was, furthermore, extremely illuminating to hear Dr. Crowe say that they succeeded in introducing cotton containing microbes from pyorrhea cavities into the frontal sinus of the dog and were thus able to produce abscess of the lung in the majority of cases by gradual aspiration of the secretion from the infected sinus.

Regarding diagnosis, our country is advancing ahead of the majority of other countries in that bronchoscopy is used early in these cases.

In our well conducted hospitals there is prompt cooperation between the various departments. The diagnosis is not simply left to the internist and the surgeon, everywhere the roentgenologist and bronchoscopist are called in at once. We work hand in hand—physician, surgeon, bacteriologist and roentgenologist, and then we promptly call on our experienced bronchoscopist.

And so it has come about that we follow a certain course of events in making the diagnosis in establishing the indication for treatment and in starting treatment. As Dr. Kernan said this morning, let the bronchoscopist take the case in hand first, if it is not a case for prompt surgical intervention.

Personal observation has impressed a few points deeply on my mind. It was hard for surgeons at first to transfer these cases to the bronchoscopist, but the results that I saw were so phenomenal that I considered it the duty, not only of myself but of every general or thoracic surgeon called on to perform these operations, to refer the patients first to a trained bronchoscopist.

Dr. Kernan reported a case of the late Dr. Lynch who was consulting bronchoscopist at our hospital for a number of years. The woman, one of my patients, had foul expectoration which developed following aspiration after tonsillectomy. She had high fever, but fortunately came in a few days after the condition developed. Dr. Lynch made one of his splendid inspections and performed aspiration. All the threatening symptoms quickly disappeared, not only the rise of temperature and the general malaise, but the expectoration. It was hard to believe that a single seance of bronchoscopy and aspiration could accomplish such a result. The patient left, and it was hard to trace her again. We ascertained that she was well after three or four years.

Then, in preparing a paper on suppuration of the lung and collecting and following-up cases of patients whom we had treated, we were astonished to find that not only patients with an acute condition were cured by bronchoscopy, but also that those with subacute and even chronic cases were much improved, some were cured.

That peroral endoscopy cannot cure them all is understood but, to my mind, it is the duty of every surgeon to call on the experienced bronchoscopist first and let him show what he can do, not only by aspiration, but by conscientious and faithful endobronchial treatment. If he fails, the case will become one for surgical measures.

We know that spontaneous healing without surgical intervention occurs in about one third of the acute cases due to aspiration, of course, I shall consider these principally because I believe that aspiration is the most frequent etiologic factor. We should make it clear to ourselves that it is impossible to find out

pointed out that such perforations usually occur only in the early stages of an abscess near the surface with thin walls, and not in chronic abscesses with thick, rigid walls and a surrounding area of fibrosis. It also seems apparent that in only comparatively recent cases of abscess is artificial pneumothorax suitable for treatment, i. e., in cases in which the lung is compressible and in which there is a good outlet to the main bronchus.

These various considerations make us feel that there is a rational basis for treatment by artificial pneumothorax in cases of acute suppurative intrapulmonary lesions, and that in properly selected cases it may prove to be of great value.



DR CARL HEDBLÖM, Chicago Nontuberculous pulmonary suppuration is a comprehensive subject to cover in a short symposium, and obviously only a few points can be touched on in a few minutes' discussion

The papers presented bring out facts which seem to me to be of fundamental importance to our understanding of the subject. The question of the etiology of abscess of the lung interests me, not so much as an academic discussion, as because of its practical importance. Precautions against aspiration of infected material, particularly during operations on the nose and throat, could be largely abandoned if we were to accept without further question the results of experiments on animals purporting to show that pulmonary abscess following such operations is, as a rule, a blood-borne infection.

The experiments on animals cited in support of this view seem to me do not warrant such an assumption. We know that if gross infected material is introduced into the general venous circulation, it will be sifted out in the lung, and that abscess of the lung should follow does not seem surprising. But this does not prove that this is the mechanism by means of which infection reaches the lung in man following tonsillectomy, for example, nor does it exclude the possibility of infection by inhalation. Furthermore, the failure to obtain abscess of the lung in the dog in a hundred animals or less loses significance when it is considered that the incidence of abscess in man is only one in several thousand.

It has also been shown that pulmonary abscess may be produced in dogs and other animals by infection by inhalation. Other considerations also point to infection by inhalation as playing the most important rôle in postoperative pulmonary abscess. Among such may be mentioned the ease with which animals inspire foreign material into a bronchus during anesthesia, the demonstration of blood in the trachea in a large proportion of patients following tonsillectomy, the relatively large proportionate incidence of postoperative abscess following deep general anesthesia, particularly if the patient is operated on in the sitting position, and the finding of teeth or fragments of them following extraction under general anesthesia in abscesses producing similar clinical manifestations. Such abscesses that I have opened have been situated in the periphery of the lung. Furthermore, precautions against aspiration of infected material, local anesthesia or light general anesthesia, with the head lower than the body, suction, careful hemostasis, etc., have reduced the incidence of post-tonsillectomy abscess to almost nil in many clinics with a record of thousands of cases each.

Dr Crowe's experimental production of pulmonary abscess in dogs following infection of the frontal sinus seems to me to be of fundamental importance. The resulting discharge of pus into the nasal passages would seem to furnish conditions favorable for inhalation, but not for blood-borne infection in the lung.

The treatment for pulmonary suppuration, as Dr Lihenthal has properly emphasized, must be individualized. The term includes essentially abscess, bronchiectasis and their combinations. Pulmonary abscess may be single, multilocular or multiple, central or peripheral, acute or chronic, and treatment to be rational must necessarily take into account the varying pathologic processes and location. The various methods of treatment—postural drainage, bronchoscopic dilatation and lavage, pneumothorax collapse and thoracotomy drainage—find their indications according to the nature and location of the abscess.

A centrally located abscess—near the hilum—is the type most suited for conservative methods: postural drainage, lavage, pneumothorax collapse. Such

Bronchiectatic dilatation, with the exception of certain congenital and generalized forms, is constantly met with in suppurative foci within the parenchyma of the lung. This seems to be related to a destruction of the elastic fibers which normally form such an intimate and important structural item of the bronchial wall. In sections of lung tissue in which suppurative processes are taking place, this destruction forms a prominent part of the histologic picture.

Suppurative metastatic empyema usually indicates an embolic lesion either in a small vessel of the pleura or in superficial parts of the lung. In either case, a focus of suppuration forms which ruptures into the pleura. In cases of general infection, foci of infection of this variety are frequently found in the midst of the parenchyma of the lung as so-called "furuncles", only those result in empyema which are sufficiently near the visceral pleura so that it is mechanically easier for the pus to rupture into the pleura than into the bronchial tree.

In approximately 71 per cent of the cases of bronchopulmonary suppuration and empyema in this series of cases of empyema, some form of bronchopulmonary fistula existed which communicated with the operative wound in the wall of the chest by way of the empyema cavity. It is likely that more of these existed, but in the other cases the fistula was undemonstrable. A distinction should be made between those fistulas which reach into any but the smallest of the bronchi and those which reach into the pulmonary parenchyma. The first of these are easily recognized, are fairly large, are sometimes multiple, are associated frequently with large empyema cavities and with collapsed lungs, are difficult to heal, commonly are subject to secondary operations and frequently persist in spite of all that one can do. The second are difficult to recognize, except by the test with a surgical solution of chlorinated soda (Dakin's solution). They are associated with smaller empyema cavities, usually do not materially delay the healing of the cavity and practically never are a sufficient cause for secondary operations, in almost all of the cases, the empyema cavity heals.

In metapneumonic empyema, the disturbance created by the production of the empyema is commonly at a minimum. The nature of the process lends every assistance to this condition. Commonly there is a preexisting pleurisy over the involved area, and adhesions usually occur. The progression of the lesion is comparatively slow, the rupture of the superficial abscess takes place concomitantly with its efficient localization by adhesions, and the static conditions within the thorax are not disturbed. The communication with the interior of the pulmonary parenchyma is comparatively small and is further rendered futile, often only temporarily, however—by the pneumonic exudate surrounding and plugging it, thus effectually blocking any immediate free communication with a bronchus. I have appreciated the latter fact forcibly on many

ported by the cellular and noncellular elements delivered in the blood. Adequate repair leads to undelayed healing which in structures of the lung can be well nigh scarless. Inadequate repair protracts convalescence, increases cicatrization, and inflicts permanent disabilities of a peculiarly burdensome type, because they impair cardiac as well as pulmonary functions.

Bronchopulmonary structures possess extraordinary native powers of resistance, defense and repair which differ little between individuals. Susceptibility to infection, inadequate defense against infection and inadequate repair of tissue destroyed by infection are attributable mainly to deficits in the quality of blood delivered to the affected lung.

The obvious obligations of therapists in combating pleurobronchopulmonary inflammation are (1) to help improve the quality of blood in circulation, (2) to promote deliveries of the maximum unit volume of blood to unit volume of affected lung, (3) to reduce but not to abolish the excursions of the lung because abolition would cause hypemia, and (4) to minimize cardiac effort.

1. Quality of blood in circulation improves with rest, diet, fresh air, sunshine, medication by mouth or intravenously, and transfusions of unmodified blood repeated as needed. Blood transfusions are supposed to be dangerous or useless in treating persons with intrapulmonary conditions, and, as frequently given, this is correct. Too large transfusions of blood and those given too rapidly cause acute cardiac dilatation which often kills. Blood treated with the anticoagulants now available is unduly irritating, it frequently provokes severe, and occasionally some lethal, reactions. Its leukocytes are injured, and, more significant still, the antibody content, the most serviceable of noncellular elements, is impaired.

2. Maximum unit volumes of blood are delivered to unit volumes of lung when the lung is in a position of incomplete deflation corresponding to reduction but not to abolition of intrapleural negative pressures. In this position, the intrapulmonary vessels are neither more tortuous as in more advanced deflation nor more elongated as in greater inflation. Peripheral intravascular resistance is least, and cardiac power propels the most blood.

3. Reduction but not abolition of pulmonary excursions occurs when the excursions of the thoracic parietes are correspondingly restricted.

4. Cardiac effort is least when the peripheral intravascular resistance is least. This obtains if the excursions of the lung are restricted to those just above and just below the mean between full inflation and full deflation, and the patient is inactive.

A lung can be placed in the most propitious position which at once raises its powers of resistance, defense and repair to the optimum and minimizes cardiac labor by two procedures. Pneumothorax can be induced if pleural adhesions are absent, and the intrapulmonary negative pressures reduced. This adds another irritant, provokes pleuritis, is transient and cooperates but inexactly with natural responses. The diaphragm may be paralyzed by the blocking of the branches of the phrenic nerve that transmit motor impulses to the diaphragm. This exactly resembles the responses in man and animals to divers forms of spontaneous and induced pleuropulmonary irritations. Paralysis of the diaphragm automatically restricts costal excursions and assures the physical conditions most favorable for recovery. Paralysis and consequent elevation of the diaphragm, partial pulmonary deflation and reduced vital capacity are undesirable in health. Paralysis can be made transient by temporary blocking of the phrenic trunks bearing motor impulses (*phrenemphraxis*), or, when indicated, permanent palsy is induced by extracting those trunks (*exeresis*).

within the pulmonary parenchyma until the surface of the lung is reached and the visceral pleura is destroyed. As adhesions between visceral and parietal pleura have preceded this advancing destruction, an abscess cavity is produced, one wall consists of lung tissue and the other of the parietal pleura lining the interior of the thorax. These cavities are usually circumscribed, and they most commonly exist in the posterior angle of the lung near the ligamentum latum pulmona, they are less commonly present in the lateral aspect of the lung.

Clinically, this lesion is sometimes mistaken before operation for a localized empyema of the ordinary variety, and the pulmonary origin is surmised only when the physical characteristics of the cavity are determined on the operating table. Multiple bronchial fistulae usually occur. The pathologic picture reproduces that artificially made many times when operations are performed for bronchopulmonary suppuration without empyema, especially when a bronchostomy is established. Clinically, the course in this variety of bronchopulmonary suppuration with empyema is satisfactory after simple incision and drainage, the fistulas close spontaneously, and the wound heals in the largest proportion of the cases.

The observations made in regard to the mechanism by which lesions of the lung (pneumonia and bronchopulmonary suppuration) are complicated by empyema are most important, as they teach that the commonest varieties of this disease ordinarily occur only in the presence of a destructive lesion in the pulmonary parenchyma the progression of which secondarily involves the pleura by acute perforation or by chronic penetration. So far as the empyema is concerned, there is no essential difference in the mechanism, whether the primary lesion is pneumonia or whether it is an abscess of the lung, the important point to remember is that in either case there is necessarily present a communication with the interior of the lung or the bronchi or both. The difference, if any, is one of degree of virulence and toxicity of the offending organism, of the rapidity with which the process advances, with which the lung tissue is destroyed and with which the perforation takes place. The result varies with the presence or absence of pleuritic adhesions near the pulmonary process, with the size of the perforation and its communicability with one of the larger bronchi. The size of the latter has mathematical relationships with the character of the initial pneumothorax, with the resultant disturbances of the static and dynamic conditions within the thorax and with the severity of the clinical manifestations presented. The whole picture is built around the presence of a bronchopulmonary communication.

The demonstration of a bronchial fistula therefore necessarily furnishes indubitable evidence of the presence or preexistence of a sup-

empty into the thoracic duct or the large veins. There is no flow of lymph from the head to the lungs, and many valves protect the lungs against backward flow from bronchial and pulmonary lymph nodes. These lymph nodes have afferent and efferent vessels, and if infectious material passes the last of the nodal chain, it will be poured through the thoracic duct into the right side of the heart and directly to the lung as from the cervical lymph nodes. When bronchial and pulmonary lymph nodes are infected from the head, they have received that infection from the lung, which has been infected by aspiration or by blood from the right side of the heart. One must always remember that a lymph node may rupture, this is an exceptional occurrence, however.

When dealing with chronic lesions of the lung, tuberculosis must first be excluded. This is not easy. Roentgen-ray examination is essential, but may not be sufficient. The subject is too large for this discussion. It is, important, nevertheless, that the bronchoscope should not be passed, iodized oil injected or operation considered until the existence of tuberculosis has been proved or disproved.

The discussion of unresolved pneumonia brings up the question of tuberculosis. The basal type of tuberculosis is a form of unresolved pneumonia, and one is not able to differentiate the various etiologic factors by roentgen-ray examination.

I know of no place in the world where one can learn more about lesions of the chest than one can at these meetings.

DR FREDERICK T. LORD, Boston. I should like to refer for a moment to unresolved pneumonia which as an internist I feel I should defend before a body of surgeons. It has been spoken of as of rare occurrence. In our experience, organizing pneumonia is found at autopsy in about 7 per cent of the cases of genuine croupous pneumonia, and this proportion is sufficiently high to warrant its consideration as a real condition, as Dr. Pickardt suggests, in any group of complications such as those he presents. In exceptional instances, as in six of our series, organizing pneumonia was found at autopsy within from seven to seventeen days of the onset of acute pulmonary symptoms, ordinarily, however, in clinical cases a delay in resolution beyond three weeks may be regarded as evidence of developing organization and induration, provided pulmonary tuberculosis, empyema and abscess of the lung can be excluded. Improvement in roentgen-ray technic and in the interpretation of roentgenograms make it comparatively easy to avoid confusion of unresolved pneumonia with other conditions.

The explanation of unresolved pneumonia is doubtless to be found in the chemistry of the exudate. Resolution is probably accomplished by local increase of cells (enzyme), diminution of serum (anti-enzyme) and shift to an acid reaction. Delayed resolution may be ascribed to a disturbance in the local ferment-antiferment balance. If there is a shortage of cells or an excess of serum, resolution may be delayed or fail to take place.

Referring to bronchoscopy in diagnosis and treatment, bronchoscopy is chiefly of service in the recognition of bronchial occlusion which occurs with surprising frequency in connection with bronchopulmonary suppurative lesions, and which is usually due to a foreign body, tumor, granulation tissue or a cicatrix. I especially want to emphasize, without going into detail, that important evidence may be obtained regarding the presence of bronchostenosis by other means than the use of the bronchoscope. It should be appreciated that there is a significant evolution and grouping of symptoms when a foreign body or tumor is the cause of the disturbance. As regards physical signs, there may be indications of

constant reinfection of the empyema cavity from the interior of the lung by way of the bronchopulmonary fistula and (2) certain static and dynamic conditions which have to do with the relative size of the main bronchus, the opening in the wall of the chest and the size of the fistulous tract

There are two causes for reinfection of the empyema from the interior of the lung (1) an undrained or incompletely drained abscess of the lung, and (2) a persistence of infection in some part of the bronchial tree in relation with the sinus and the empyema. Both of these are equally important, and of the two, it is most difficult to contend with the persistence of infection in the bronchial wall. A pulmonary abscess is frequently prevented from healing by the smallness of the opening by which it is drained. Infection in the bronchial tree (suppurative bronchitis) is kept up (1) because of the character of the organisms which are present, (2) because of constant reinfection from a communicating abscess of the lung and (3) because of small areas of necrotic bronchial cartilage in some cases. In addition, the bronchiectatic dilatations usually alternate with lengths of bronchi in which relative strictures are present, and retention of pus occurs in the dilated parts.

Under these conditions, the pulmonary focus plays a more important rôle than the empyema proper, and in order to cure the patient of empyema, the pulmonary lesion must be brought under control. In my cases of empyema, the main problem has been more rarely that of the bronchopulmonary suppuration. It is my experience that the area of involvement of the lung gradually grows smaller, if given sufficient time and if proper drainage is kept up, until all that is left is one or more fistulous tracts.

The cases in which this spontaneous retrogression has not occurred have been comparatively few in my experience and have been associated with more or less marked grades of secondary bronchiectasis. In the latter, one can either perform a lobectomy when conditions are ideal or one can increase the facilities for drainage. Lobectomy is extremely dangerous under the conditions. Bronchostomy, however, is a much safer procedure, and when properly performed so that complete drainage is established, the induration surrounding the abscess gradually disappears. Partial lobectomy performed with the cautery is only a form of bronchostomy.

The resultant bronchopulmonary fistula has been the more frequent problem. Those that give the most trouble are associated with bronchopulmonary forms of suppuration. The plan that I have found to be the best has comprised two objects (1) the control of infection within the sinus and the bronchial tree so that one could have comparatively uninfected territory to deal with and (2) the obliteration of the empyema cavity.

lung, or empyema which has ruptured back in the lung. All of the cases occurred in adults, and all were characterized by a history of the patient's having had, about a year previously, an acute inflammatory disease of the lung that had quieted down and had left the patient only moderately ill and without fever, but with a daily output of sputum, little appetite, and unable to continue his work. Regardless of the exact character of the lesion, as it had been present for a long time and was situated in the lower lobe, it seemed reasonable to assume the fixation of this lobe by adhesions and further that, with the lower lobe so fixed, the rise of a paralyzed half of the diaphragm would result in definite though perhaps incomplete collapse of this diseased lobe. We tried blocking the phrenic nerve, and in a number of instances achieved the

DR E. F. BUTLER, Sayre, Pa. Simple drainage operations for pulmonary suppuration have yielded disappointing results. A lack of adequate operative access to the suppurating area and a lack of adequate postoperative control have constituted obstacles to the attainment of satisfactory end-results. Recently more satisfaction has been obtained from radical operative programs. A series of fourteen cases have provided 75 per cent of complete cure and a return of the patients to economic life. An additional 5 per cent promise to reach this same goal. In 12 per cent, the object has not been accomplished. The mortality has been 8 per cent.

The basic strategy in these cases has been to conserve lung tissue and function at the expense of the anatomic structures of the chest wall proper. The tactical accomplishment has depended on creating a wide window in the wall of the chest overlying the pulmonic lesion, and through this to maintain tactile and visual control over the suppurating area until it has become clean enough to permit of closure of the defect in the wall of the chest by a skin-muscle flap prepared at the first stage operative approach.

DR FRANK TORFK, New York. I should like to make a remark in reference to the academic question which has been brought up as to whether there is more blood or less blood in the lung after collapse. All matter is subject to certain physical laws, and the lung is no exception. If pressure is exerted on any part of the body, for instance on the skin, there will be less blood in it, it will be blanched. If, on the other hand, suction is applied, the pressure thereby being diminished, the result will be more blood under the area so treated. If neither pressure nor suction is used, and the condition normal, the amount of blood in the part will be intermediate between the two extremes of diminution by pressure and increase by suction. In the case of the lung, there must be, as Dr. Lilienthal said, a diminished amount of blood, if the lung is compressed. I do not think anybody will deny that. But there seem to be differing beliefs as to the relative amount of blood in the collapsed (not compressed) lung and the distended (normal) lung. If a collapsed lung is brought into a negative pressure chamber, so that it will expand to the normal dimension, there is an exact counterpart of the skin area mentioned before as being under the influence of suction. By thus diminishing the pressure on the outer surface of the lung, a greater amount of blood must infallibly be drawn into the organ. In the normal thorax this condition of diminished pressure, negative pressure, on the outside of the lung constantly exists, nature establishing it so that a maximum amount of blood may be sent to the lungs for oxygenation, and with each inspiration the suction on the outer surface is increased with a consequent increase in the amount of blood entering the lungs, whereas the expiratory effort drives it out again. The parallel between the blood in the lung and that in the area of skin mentioned before may seem

## REPORT OF CASES

CASE 1—A young woman developed a posttuberculosis abscess of the lung and a pyopneumothorax. The empyema was drained and a bronchostomy was established. Multiple bronchial fistulas were present and a copious discharge of mucus persisted for months. Then the indurated portion of the lung was progressively destroyed with the cautery, and subsequent roentgenograms showed a progressive diminution of the indurated area. Clinically, there was a similar diminution in the amount of the discharge and a coincident marked improvement in the general condition of the patient. At the present time, there is a comparatively small shallow cavity lined with granulation tissue, in the bottom of which are a number of minute bronchopulmonary fistulas. The discharge is at a minimum. Time will be a great aid to this patient.

CASE 2—Following incision for a large empyema with collapse of the lung a young man had a large cavity in which bronchial fistulas were present. A roentgenogram of the chest showed an absence of an indurative process in the lung. Finally a thoracoplasty was performed in which the wall of the chest was collapsed. The wound healed down to several narrow sinuses, which persisted for more than a year before they closed. When this article was written one year ago the wound had remained completely healed.

Epithelialization of the sinus tract so that a bronchopulmonary cutaneous fistula results is a theoretical obstruction to the final healing of any fistulous tract, I have never seen this in bronchopulmonary fistulas, either clinically or in the laboratory. While I am ready to admit that the condition is possible in large-sized fistulas which reach directly to the skin, I am convinced that if all other impediments to the healing of the sinus are removed, epithelialization of the sinus becomes an inconsequential factor.

There were six cases in this series of bronchopulmonary suppuration with empyema in which a bronchopulmonary fistula was not demonstrable at any time. Four of these patients died: one from multiple abscesses of the lung, another from a suppurative pericarditis after pericardiostomy, a third, from a pulmonary embolism, and the fourth from the effects of a general infection. The last mentioned patient also had multiple abscesses of the lung.

The absence of any bronchopulmonary communication with the empyema cavity seems to increase the gravity of the pulmonary lesion. The number of fatalities are correspondingly large, and are due to the condition of the lung. As soon as this communication becomes established there seems to be an amelioration of the entire condition. This seems to agree with the results obtained in cases of bronchopulmonary suppuration without empyema after a bronchostomy has been performed. The improvement which follows is directly proportionate to the extent and freedom of the drainage which is established.



Tufter called attention to the fact that 13 per cent of all patients with chronic pulmonary suppuration develop abscess of the brain or meningitis. Our own figures closely approach his figures. Therefore if, say, 12 per cent of the cases of cerebral embolism are added to 10 per cent of the cases of malignant disease, in 22 per cent death is likely to occur, if all the cases of pulmonary suppuration are included. Of course, surgical measures can be employed in some cases of cerebral complications, some patients with abscesses of the brain recover after operation. Unless we discriminate as to what sort of case we are talking about and deal only with pulmonary suppuration in general, we shall find that the mortality rate is high regardless of the kind of treatment.

With these words of introduction, I should like to speak about certain specific matters brought up in this symposium. One is the question of treatment in cases of refractory chronic suppurations, particularly so far as it applies to treatment with the cautery. Many consider me an ardent advocate of this kind of treatment. This radical operation with the cautery should be performed only in the most refractory cases. We start, therefore, with cases which are bad surgical risks, cases which usually have resisted other forms of treatment, including simple drainage, sometimes thorocoplasty and other types of treatment. I am rather disappointed to find that other surgeons have not had the same satisfactory experience with this operation that I have had. I am particularly disappointed to find that the subject of hemorrhage is referred to so frequently. My own experience in these cases consists of a series of forty-five cases in which my associates and I have carried out a radical cautery operation such as I have described elsewhere.

In this series of forty-five cases, considerably more than 100 extensive cauterizations have been performed, I cannot say off-hand just how many. In only one case has there been troublesome hemorrhage. That occurred in a child, aged 6 or 8, who died of hemorrhage on the twelfth postoperative day, and who was found by the nurse early in the morning lying dying in a pool of blood. We have had hemorrhage in other cases, but there has never been any difficulty in controlling it. I think that in this case the hemorrhage could have been controlled if the patient had been an adult instead of a child, and if he had notified the physician or nurse that something was wrong.

If serious hemorrhage occurs during the time that the cauterization is being performed we either clamp the large vessel which is bleeding and ligate it, or, if that is not easily done, we pack and stop, and do not continue with the cauterization at that time. We have never found any difficulty in controlling any kind of hemorrhage from a vessel that we have encountered at this operation by the simple device of packing. We ordinarily leave the pack undisturbed for five or six days, then it is removed, and a clean pack is substituted. I should say, of course, that great precautions are taken at the time of removal of the first pack. Everything is made ready to put in another pack immediately in case hemorrhage should start again. We keep the lung packed tightly for ten or fifteen days. I prefer to carry out this procedure by easy stages, multiple stages, rather than to attempt to do too much in one step.

I feel that possibly one explanation of hemorrhage that occurs to other physicians who have performed this operation or followed this procedure has been that they have not been working through a wide enough exposure. I feel that it is essential to have a free, wide exposure. This is usually accomplished by the resection of three or four ribs at the first operation, then everything is before one's eyes and one can see everything that is happening in that area of lung tissue.

# THE EMPYEMA PROBLEM \*

AMBROSE L. LOCKWOOD, M.D.

TORONTO

There are few diseases that have perplexed the profession so generally since the earliest times as has empyema. Even in this advanced era of medical development, there is no agreement as to the treatment, as is evidenced by the various methods advocated, the persistent incidence of chronic empyema and the extreme variations in mortality incidental to treatment by various methods. Because during the several stages of the disease the patient requires the attention of those specializing in various branches of medicine, every effort should be made by the medical profession to recognize the etiologic factors in the condition, to be familiar with methods of avoiding it, to make an early diagnosis and thus control the course of the condition and, if possible, to determine a more routine method of treatment with the minimum of mortality. As a rule, the patient first comes under the care of the general practitioner, he is then referred to the medical consultant, the roentgenologist, the bacteriologist, the surgeon and the anesthetist and then back to the practitioner.

Hippocrates first recognized the disease. He advised intercostal incision or trephining of the rib for drainage. His treatise on the subject was as lucid as any that have appeared until recent years. The sound advice of Hippocrates was later neglected or forgotten. For centuries following the invention of the aspirating syringe by Galen, aspiration was employed. Because of the fear of admitting air to the pleural cavity and the dread of sepsis, free incision for empyema was not practiced from the time of Galen till that of Lister. Paget,<sup>1</sup> in his "Surgery of the Chest," says

As late as 1872 Bouchut published, as an instance of good profitable surgery, a case of empyema in a boy, aged nine, cured in 16 months after 58 punctures. In another case he punctured the chest, in 11 months, 123 times.

Tilly recorded a case in which he made fifty-six punctures. Gimbert made seventy-four punctures in nine months in a child, aged 1 year. Of forty-eight patients thus tormented, only six were saved. Of twelve patients under the care of Velpeau, not one recovered. Of fifty-eight under the care of Dupuytren, all but two died. Sir Astley Cooper complained that he never obtained a cure. Is it curious that with the establishment of free drainage again in Lister's time aspiration was abandoned until that great master surgeon, Murphy, adopted it? He also injected 2 per cent solution of formaldehyde and glycerin into the pleural cavity.

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\* From the Section of Surgery, Lockwood Clinic.

1 Paget, *Surgery of the Chest*, New York: E. B. Treat & Company, 1897.

pneumothorax alone, and some have been well for five years without recurrence. They must be properly selected cases, of course. I do not want to go into this aspect too much. We have long felt that sinus disease was an important association of chronic pulmonary suppuration, and we regard the examination of nasal sinuses of just as much importance in the examination of a person with chronic pulmonary suppuration as the examination of the lung. We have had astonishing results, often we see spontaneous healing in advanced cases merely after the correction of suppuration in the nasal sinuses, this is particularly true in the cases of children.

I was much interested in Dr Kernan's report of his series of cases of bronchoscopy. So far as I know, only one other report has been published on actual results of bronchoscopic treatment in suppuration of the lung. That report does not concern any large series of cases, but is a report of only thirteen cases from the largest bronchoscopic clinic in the world, namely, the Jackson Clinic. I have been able to find only thirteen cases reported on the success of bronchoscopic treatment in pulmonary suppuration. Twenty-five per cent of the patients were reported cured, 30 per cent were reported unimproved and the rest improved.

It is interesting that bronchoscopy, according to Dr Kernan, is most effective in certain types of cases, notably the post-tonsillectomy abscess situated near the root of the lung. That type of abscess responds to treatment by rest in bed with postural drainage and heals spontaneously more easily than any other type of abscess. I think that is a point we must consider. I do not wish to imply that I condemn bronchoscopy. I think it has definite indications, but I think that we must remember that the cases which give the best results in bronchoscopy are the ones in which the abscess is most likely to heal spontaneously, excepting the cases associated with foreign bodies.

DR LIEBENTHAL. Dr Graham's report simply substantiates what I said about discharging patients who are not absolutely cured—those who have uncured abscesses, those who have bronchial stomas and those who have any signs that the lung is not well. They may have recovered from the operation and have been clinically cured, but for a long time one cannot tell whether or not they will die from some condition that was connected with the original disease for which they sought treatment. Dr Graham has said this himself. I am not objecting to treatment with the cautery. On the contrary, I think that if properly performed in suitable cases the results are undoubtedly good. We know that Graham's results have been excellent. When he says that 10 per cent of the patients would die of cerebral abscess in any event, it must be admitted that we cannot know which 10 per cent they are. But I maintain that with operations of a kind in which the diseased part of the lung is removed beyond ligatures, cerebral complication must be rare. I have not seen it in a single case in the lobectomies I have performed. It will take us a very long time to find out whether or not cerebral complication is more common after burning.

Dr Graham says that two patients died of pneumonia from one to one and a half years after operation. I would be more convinced if they had died of some disease not connected with suppuration of the lung. They died of a lung disease, and I cannot help thinking that these may have been connected with the original pulmonary infection.

I do not remember that I have ever operated to cure a bronchial stoma. I agree with Dr Graham that when the cause of the bronchial stoma is no longer present, it will be difficult to keep it from closing. I shall report a case at

When aspiration is being performed, just before the needle is withdrawn, a little alcohol or 1 per cent mercurochrome-220 soluble is introduced into the needle with a syringe, and the needle is slowly withdrawn so that the antiseptic escapes into the tract and prevents infection which is troublesome, particularly if operative intervention through the same site is necessary later

#### CHRONIC EMPYEMA

Chronic empyema must be considered the result of an improperly treated acute empyema. If the cavity is present from six to eight weeks after the development of the disease, for practical purposes it is classed as a chronic empyema. Whittemore<sup>7</sup> aptly indicated the reasons why an acute empyema becomes chronic when he said that "it is either a neglected case, and has not received surgical attention when it should have, or it has been badly operated on, or the after-care has been poorly managed." Lack of cooperation on the part of the patient contributes to an unfavorable result.

There should not be undue haste in dealing radically with the cavity. Radical operations should be decided on only after the exact location, size, nature and accurate ramifications of the cavity have been determined, and then only when, after a thorough trial with the Carrel-Dakin treatment, the application of various dyes (Kellar), blowing exercises and suction and other methods, the cavity is not being reduced in capacity. Then radical operative intervention should not be delayed, if the patient's general condition has improved as much as can be expected, with the thorax still open, and if the patient's resistance generally is such that he will stand the operative reaction to be expected.

The factors contributing to persistent drainage in these patients are

- 1 Necrosis of the bone or cartilage adjacent to the sinus
- 2 A drainage opening that is not dependent
- 3 A foreign body within the cavity
- 4 Extensive fibrosis about the sinus tract that will not permit healing
- 5 Multiple pockets within the cavity that do not drain dependently
- 6 Such extensive thickening over the visceral pleura that the lung cannot possibly expand farther
- 7 Adhesions to the mediastinum, diaphragm or pericardium
- 8 Tuberculosis, syphilis, pyocyaneus infection and actinomycosis

In all cavities that will contain more than 3 ounces (89 cc), it is the practice in the Lockwood clinic<sup>8</sup> to endeavor to expand the lung to the wall of the chest rather than to collapse the wall of the chest to the lung. In most cavities under 3 ounces (89 cc), especially if peripherally placed,

7 Whittemore. Personal communication.

8 Lockwood, A. L. The Scope of Thoracic Surgery, *Arch Surg* 10 280 (Jan) 1925.

# COUGH

## ITS ACTION ON MATERIAL IN THE TRACHEOBRONCHIAL TRACT EXPERIMENTAL STUDY \*

EDWARD ARCHIBALD, M D

MONTREAL

AND

A LINCOLN BROWN, M D

SAN FRANCISCO

If one were asked the question "What is the function of cough?" the reply would probably be that it is to clear the respiratory tract, of either an irritant or a block to the free passage of air in and out of the tracheobronchial tree. Thus, the general conception would be that the act of coughing results in an expulsive force which tends to drive whatever substance is producing the irritation, or block, up and out of the respiratory tract. The purpose of the experiments under consideration was to determine, whether or not this was the sole result of the act of coughing on material in the tracheobronchial tree. For, it had occurred to one of us,<sup>1</sup> as doubtless to many others, that cough, under certain circumstances, might actually be the means of spreading the material which produced the irritation deeper into the finer ramifications of the pulmonary tree rather than of expelling it.

### PHYSIOLOGIC CONSIDERATIONS

While cough may be voluntary, it is generally a purely reflex and unconditioned response to local irritation in the air passages originating nerve impulses which are transmitted by afferent fibers in the vagus nerve. The efferent portion of the reflex arc is completed through motor nerve fibers innervating the intrinsic and accessory muscles of respiration. The excitation of these motor nerves results in a contraction of the muscles involved. The abdominal muscles contract, bringing about an increase in intra-abdominal pressure which is transmitted through the semirigid diaphragm into the thoracic cage. The intercostal muscles, aided by the abdominal and lumbar groups, tend to elongate the bony frame-work of the thorax and thereby markedly decrease its average diameter. The accompanying contraction and fixation of the diaphragm further narrows the chest cavity and completes the contraction of the boundaries of the thoracic cage, except for the upper segment represented by the neck. This is held rigid by the long muscles of the neck, leaving only the exit through

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\* This article appeared also in *Am Rev Tuberc*, August, 1927

1 Archibald, E. *Am Rev Tuberc* 15 564, 1927

absorption of the fibrinous barrier between the alveoli, and that there are more failures in obtaining complete expansion following decortication in patients operated on with cavities of from six to eighteen months' duration than in those with cavities of longer duration

Delorme,<sup>11</sup> having noted the degree of expansion possible in lung tissue in old empyema cavities examined at autopsy, operated on a patient in 1894. He reported little trouble with the actual decortication itself, but the patient died of shock and hemorrhage. American surgeons did not take kindly to the procedure, and in 1913, Beckman<sup>12</sup> could find only twenty-four cases reported in the literature, all the operations were performed by three operators. Ransohnoff,<sup>13</sup> after the experiences of Fowler and Delorme, modified the operation, making multiple incisions at right angles. There are a percentage of patients in whom the pleura will not strip, and the methods of Ransohnoff must be resorted to although expansion is never so complete. Beckman's advice "to attempt decortication first and, when it fails, to try other methods" should be followed. It has been our experience, however, that a minor preliminary operation to secure adequate drainage and permit proper irrigation according to the Carrel-Dakin method has been necessary in over 9 per cent of patients who have come under our care in the chronic stage of the disease. Robinson<sup>14</sup> stated that nine tenths of his patients required such a preliminary operation.

We have so modified our method of decortication that we rarely have any trouble at the time of operation or after from the operation per se, but it must be borne in mind that to get the most complete result from a decortication, the incision must be hermetically sealed so as to establish a negative pressure and maintain the reexpanded lung in expansion. This is not always easy in cases of long standing in which the patients have had repeated operations with removal of tissue and loss of elasticity of the tissues about the scar and in the presence of extensive scars with a poor blood supply. If the incision is hermetically sealed, the patient must be closely watched for the development of intrapleural pockets, and repeated aspirations must be performed to keep the thorax free from fluid.

On the whole, however, a certain amount of the wall of the chest has had to be removed in most instances, so that in addition to methods of expanding the lung a means of dealing with the wall of the chest itself must be considered to allow adequate drainage, inspection and manipula-

11 Delorme. *Seventh Congress de Chir. Paris, 1893*

12 Beckman, E. H. *Decortication of the Lung for Old Empyema*. Northwest Med., vol. 6, 1914

13 Ransohnoff. *Ann. Surg.* 43: 502, 1906

14 Robinson, Samuel. *The Treatment of Chronic Nontuberculous Empyema*. Surg. Gynec. & Obst. 22: 557, 1916, reprinted by the Mayo Clinic 7: 612

Thus, two *a priori* factors whereby cough may actually spread material deeper into the pulmonary tree rather than merely expel it, may be considered, namely (a) the inspiratory rush of air and (b) the expiratory effort

#### THE INSPIRATORY RUSH OF AIR

It is obvious that a single cough does not always clear the pulmonary tree of the irritating substance. Therefore, it may be assumed that in many instances this irritating substance is acted on by the increased inspiratory rush of air which follows cough and which may possibly carry it, or a portion of it, on into the finer bronchioles or even into the alveoli (fig 1). In case the entire mass has been transported by the inrush of air, either in toto or in a subdivided state, the situation is one in which a substance which originally was in a sensitive area of the pulmonary tree is now in a region where its presence does not produce a stimulation to cough. Even if most of the substance is subsequently

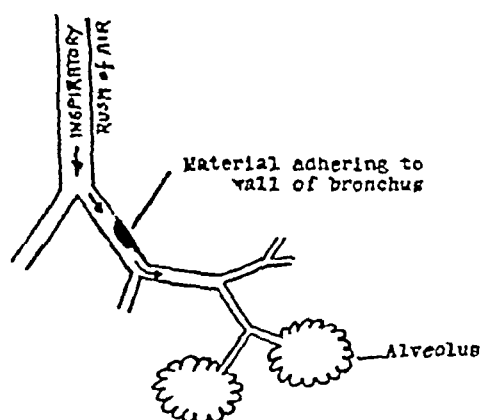


Fig 1—Showing how the increased inspiratory rush of air that follows cough strikes substances in the tracheobronchial tree and may spread them into the finer alveoli

expelled by cough initiated elsewhere, it is still clear that a chain of events takes place whereby particles may be transported, by one phase of the act of coughing, downward into the finer ramifications of the pulmonary tree, where they may come to rest. If, now, the material is of an infective nature, a pathologic process may be initiated

#### THE EXPIRATORY EFFORT

Since the advent of the use of opaque substances for the roentgen-ray and fluoroscopic visualization of the pulmonary tree, it has become possible to witness what actually occurs during cough, and several reports of the spreading action of cough have appeared in literature. For example, Ameuille<sup>4</sup> injected iodized oil 40 per cent into the right lower

4 Ameuille. Injection transparietale de lipiodol dans une caverne pulmonaire, production sous l'écran du phénomène de l'embolie bronchique, Bull et mem Soc med d hôp de Paris 98 791, 1924

## CONCLUSIONS

The closure of a chronic empyemal cavity is a mechanical problem. The general health and resistance of the patient must be appreciated. The exact size and ramifications of the cavity must be determined by roentgen-ray examination and by direct inspection and measurement of the cavity. Adequate drainage must be secured. Carrel-Dakin irrigation must be carefully and thoroughly carried out so that every surface of the cavity is bathed in the fluid. Blowing exercises must be begun. Every effort must be made to build up the general health of the patient, and, finally, with proper appreciation of the risks, difficulties and sequelae of the operations and the resistance of the patient, the lung must be expanded and the wall of the chest collapsed, so as to obliterate the cavity. Multiple small operations safely carried out reflect the sound judgment of the surgeon. A patient should not die in the chronic stage of the disease, except from tuberculosis, actinomycosis or lardaceous disease in the late, neglected type of case.

Postoperative death of patients with chronic empyema gravely reflects on the surgeon. Robinson states that "An operative fatality in chronic empyema is inexcusable." I agree with him.

## ABSTRACT OF DISCUSSION

DR HOWARD LILIENTHAL, New York. I have been greatly interested in these constructive papers.

Dr Crowe's paper is an epoch marking contribution, in it he tells how he showed experimentally in the dog, an animal in which it is especially difficult to produce pulmonary suppuration, how the production of a sinus suppuration was followed by typical abscesses of the lung. The specimens were convincing and the paper most instructive.

Dr Crowe spoke of chronic abscess of the lung caused in this way, I should say that such an abscess would become chronic only after it had been an acute abscess. I cannot conceive of an abscess of the lung as being chronic from the beginning. Perhaps I am a stickler for words, but I would suggest some change in the terminology, perhaps calling it a slowly progressive abscess.

As regards hemorrhage as a cause of death in dogs, I do not know what the experience of others has been, but in my observation hemorrhage has been an extremely common and dangerous complication of gangrenous abscesses of the lung, especially in bronchiectatic cases. The process is a true spreading gangrene with ulcerations in the vessel walls, not only of the pulmonary but of the bronchial system of arteries. I am sure that these hemorrhages occur because of the spreading gangrene, the destructive inflammation.

I should like to hear the opinion of others as to their experience. I think that I have had more deaths from hemorrhage in cases of suppuration of the lung than I have had in cases of tuberculosis.

I think that Dr Crowe mentioned something about massive collapse. I do not believe massive collapse of the lungs is always inspirational. It has been difficult to prove because so few of these patients die, but recently a case was



sputum into which the oil was injected by means of a very fine needle and syringe in the proportion approximately of one part of oil to two of sputum

The experiments must further be subdivided into (a) instances in which no attempt was made to induce cough, (b) instances in which cough was induced by mechanical stimulation of the posterior pharyngeal wall and (c) instances in which in addition to the mechanically induced cough an artificial block to the expiratory force was present. This block was produced by compression of the upper tracheal segments through the pretracheal tissues with the fingers

The method of introduction consisted, first, in general ether anesthesia sufficient to abolish cough but light enough so that cessation of anesthesia almost immediately brought about a return of the cough reflex. The introduction of the iodized oil alone or the iodized oil-sputum emulsion was carried out in

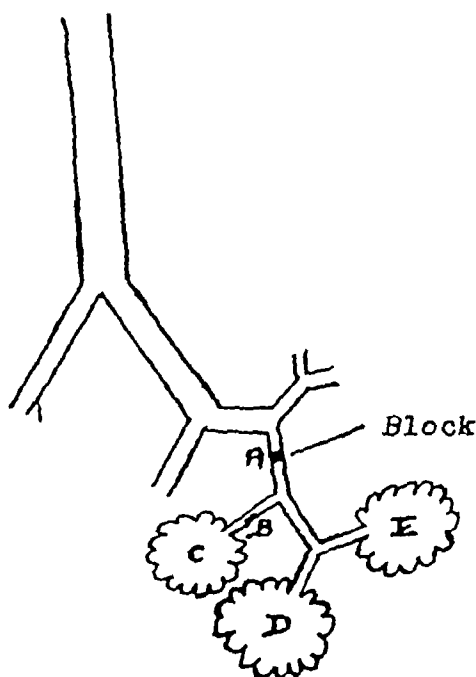


Fig 2—Showing mechanism whereby material may be driven distally by cough or spread into neighboring alveoli when a block exists proximal to the material in question. Thus, it is assumed that a block exists at *A*, then the material *B* approaches *A* during cough and immediately afterward is carried distally toward or into the alveolus *C*, or possibly into other alveoli distal to the block, such as *D* or *E*.

2 cc amounts by the intercricothyroid route after first determining the position of the needle in the trachea by the free aspiration of air into the syringe. It was necessary to perform a tracheotomy for the introduction of the thick sputum masses which had been injected with the iodized oil. This was done through a tight fitting tracheotomy tube with the cannula in place, so that all respiration went on through the tracheotomy opening and none by way of the pharynx. Moreover, because these large masses of sputum tended to block the trachea, it was found advisable to introduce them at the onset of the inspiratory effort, so that they would surely be carried as far as the bifurcation and thus allow at least partial respiration to proceed. When narcosis was established, the animals, fastened on an animal board, were

infection along that route by way of the lymphatics has been clearly demonstrated by many, yet it has so often been overlooked that it seems to me wise to call attention to it again

There seems to be little doubt that emboli cause infarctions with subsequent infections. It seems proved that aspirations from various places in the upper respiratory tract cause bronchopneumonia that may precede bronchiectasis.

The differentiation made not only during clinical examinations, but during autopsy seem important. In bronchopneumonia the areas of infection spread to the tissues of the lung immediately surrounding the bronchi. In lobular pneumonias patches of infection are seen in the parenchyma of the lung that may or may not be confined to the region of the bronchi.

Then there are cases of pneumonitis, if one wishes to call them such, which are diffuse infections spreading along the trabeculae and subpleural planes in a manner similar to that in which infections spread in other parts of the body. There are so many cases that follow operations performed under local anesthetics, so many cases in which there have been infections of the lung due, I think, to seasonal variations in the types of infections, and so many that show infections that apparently have started in the lobular or in the parenchymal part of the lung without explicit juxtaposition to bronchi or absolute evidence of their origin by vascular route, that one is forced to consider that antigen gains entrance to the lung by the lymphatic route to act as a predisposing if not exciting cause.

It seems to me important that to keep one's mind open to the distribution of these infections by all three routes—blood, bronchi and lymphatics—instead of being too sure that any one of these routes is responsible for the spreading of all infections.

DR. WILLY MEYER, New York. The various speakers have covered the entire field thoroughly. Regarding etiology, I believe that when the question of abscess of the lung being due principally to embolism came up about two years ago, many who had observed these cases carefully, said to themselves "Surely many of these cases are due to embolism." How can it be different? A septic embolus driven into the pulmonary artery or its branches must produce infection of the lung—but from what we have seen, observed and learned in the course of many years, it seems improbable that embolism should be the principal cause of abscess of the lung.

First, let us consider the aspiration that we have seen in so many instances following tonsillectomy. I know that up to this day many laryngologists insist that it is not the aspiration of blood and mucus accumulating in the pharynx during the operation which caused this terrific consequence to the patient, but that it is embolism. To the majority of us that does not seem to be the real explanation.

Furthermore we had observed abscess of the lung following aseptic operations performed under general anesthesia, for instance after an ovariectomy also after an operation for strangulated hernia, performed by other surgeons. In both patients perfect aseptic healing occurred, and yet an abscess of the lung followed, in one instance complicated by a sacculated empyema.

How could that be due to embolism? There was aspiration during general anesthesia, and as the patients aspirated some of the contents of the stomach it was fortunate that the stomach had been kept empty before operation and that far-reaching gangrene of the lung did not follow.

material failed to enter the trachea, having been injected by mistake into the pretracheal tissues. In four instances in which it was impossible to elicit cough within the allotted time, anesthesia was stopped and the animals were taken as controls of the rate of expulsion of the oil when cough had not been induced. In the eleven other instances, satisfactory cough was obtained, in five cases without tracheal compression and in six with compression. In some only one strong cough, while in others as many as twelve successive coughs were induced. All the animals coughed more or less strongly on coming out of the anesthesia, and several were observed to swallow material which had apparently been coughed up. Roentgenograms taken on successive days showed the length of time the opaque substance remained in the lungs in sufficient quantity to cast a shadow by roentgen ray. A comparison of the roentgenograms showed that, on the average, infiltration of the pulmonary tree with the opaque substance took place more rapidly and more completely with cough than without, and this observation was still more pronounced with cough plus tracheal compression. Figures 3, 4 and 5 are examples of the degree of penetration under these three conditions, all taken three minutes after the introduction of the oil, and in figures 4 and 5 within one minute after cough had been induced, in the latter case with tracheal compression. Moreover, it was noted that the oil tended to remain longer in the lungs of those animals in which cough had apparently caused a deeper penetration, and that it remained longest in those instances in which tracheal compression had been employed. This was probably due to the fact that with induced cough, and especially with cough plus tracheal compression, a larger quantity of oil reached the alveoli than was the case when the flow of the oil was uninfluenced by artificial factors.

Figures 6, 7 and 8 correspond with figures 3, 4 and 5 in that they are subsequent roentgenograms of the respective cats. They illustrate comparatively the amount of iodized oil remaining in the lungs. Thus, figure 6, taken one day after figure 3, shows practically no iodized oil remaining in the lungs, cough had not been induced in this cat. Figure 7, taken four days after the introduction of the oil in a cat in which cough had been induced, shows a considerable quantity of the oil still in situ, while figure 8, taken twenty days after the introduction of the oil, shows the greatest quantity of the oil remaining after the longest period. It is, of course, to be understood that the amount of oil present and the length of time it remained in the lungs differed somewhat at every trial, but the illustrations demonstrate fairly the type of variations noted under given experimental conditions. The actual presence or absence of the oil in the finer bronchioles and alveoli was further demonstrated in every case by frozen sections stained with scarlet red or sudan III.

in whom spontaneous healing will occur, and we should not wait and trust to luck and posture with general treatment, but we should refer the patient to the bronchoscopist. If the bronchoscopist cannot accomplish the desired result, then I believe we should resort to artificial pneumothorax, unless the patient requires surgical measures. Personally, I would not start with artificial pneumothorax.

Speaking of conservative surgery, I think, that the establishment of a permanent opening into a smaller or larger bronchus is one of the best conservative treatments in cases of infection of the lung. We called this method lung lip fistula in order to express the idea that it is not expected to heal quickly, others have called it bronchostomy. In a number of instances these patients improved materially, the fistula later healed spontaneously or almost completely, and it did not bother them. If this does not happen, I agree with Dr. Lilienthal that after a certain time one should try to close the fistula. The majority of patients are disinclined to have this done. They say, "I am perfectly well, why should I bother about it?" We all have observed that spontaneous closure occurs not so infrequently. These patients should not be left to themselves on account of the possibility of future hemorrhage.

A few words more about the remarkable case of prompt disappearance of acute pneumothorax. I also believe that if the lung collapses the explanation of the occurrence of a hyperemia of the collapsed lung is probably correct, as Cloetta has maintained. It was explained that sometimes chronic hyperemia acts so quickly also after extrapleural thoracoplasty in the tuberculous patient, that it almost forces the conclusion that it is principally responsible for the cure of some of these patients in such a brief time.

Dr. Pickhardt's presentation of the unresolved pneumonia has shown that we can prove definitely by follow-up that many of the cases which were called chronic pneumonia represent a surgical infection or condition. Two years ago, I reported a case before our association in which the condition was diagnosed first as chronic pneumonia. We might just as well have called it unresolved pneumonia or carcinoma. I would like to repeat here that diathermy, so far as therapy is concerned, had a most remarkable effect. The fever that had been present for weeks disappeared after a few applications so that the attending physician whom I had called in consultation rejoiced that his advice had had such a splendid result. I, too, was pleased, however, it was shown that at the bottom of the cause of trouble was a malignancy of the upper lobe which gradually became more conspicuous. The accompanying chronic inflammation had been beneficially influenced by diathermy.

I have one more remark to make with reference to the so-called massive collapse first described by Dr. Scrimger. Personally I was totally bewildered at first. I wondered what could be the cause of the sudden collapse other than a clogging of the bronchus. In thinking over what we had seen in animal experimentation in former years, viz., that the tying of the branch of the pulmonary artery alongside the bronchus produces rapid shrinkage and carnification of the lobe by interrupting its physiologic work, it seemed plausible that an aseptic embolism might eventually act likewise. However the spontaneous disappearance of the condition in some instances and still more the fact that prompt bronchoscopy with aspiration of a large amount of thick secretion from the respective bronchus quickly aborted some of these cases proves that actual obstruction of the bronchus produces the acute atelectasis of the pulmonary parenchyma which Dr. Scrimger called as the first acute massive collapse.

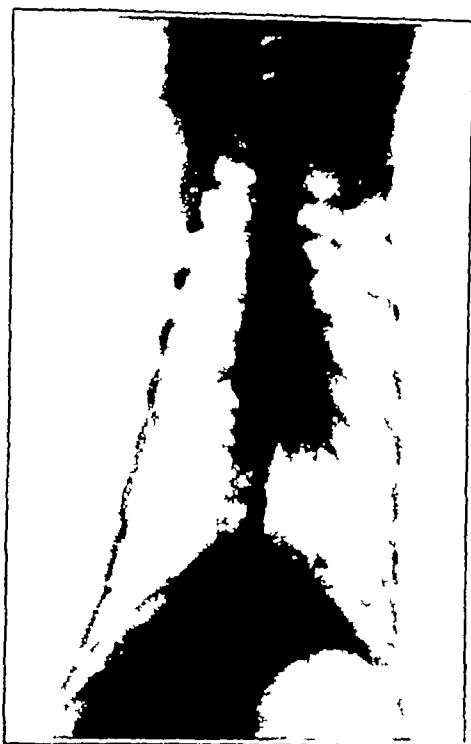


Figure 6

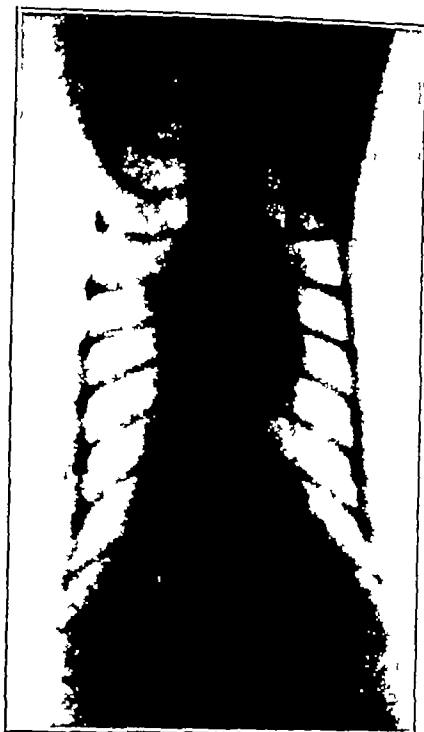


Figure 7

Fig 6 (cat 20) —Taken one day after figure 3 There is little increased density, practically all of the iodized oil having been expelled

Fig 7 (cat 15) —Taken four days after figure 4 Some iodized oil is still present as evidenced by the increased density in both lower lobes, especially the right

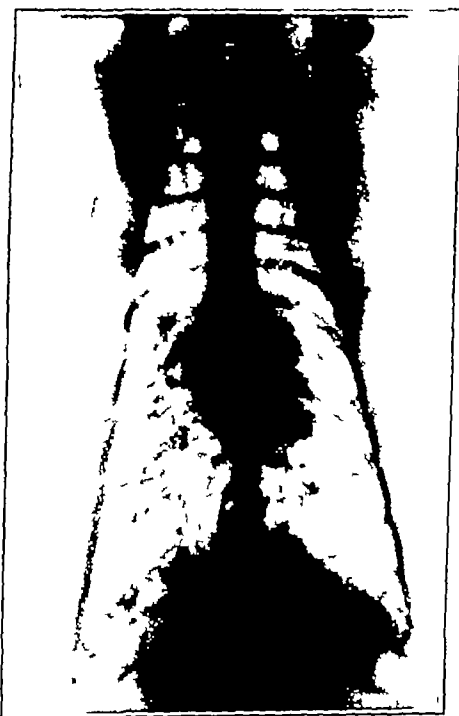


Fig 8 (cat 11) —Taken twenty days after figure 5 A large amount of iodized oil is still present, apparently in the finer bronchioles and alveoli, as evidenced by the diffuse and fine shadows cast

an abscess may be difficult to find by thoracotomy, and the danger of hemorrhage from adjacent large vessels is considerable. It is most favorably situated for adequate drainage through an adjacent large bronchus. A peripherally situated abscess draining imperfectly through a relatively long sinus connecting it with a main bronchus, especially if it is large and shows a fluid level, in my opinion, should be drained. The nearest exit for the pus is through the wall of the chest. Enlarged cavitation, hemorrhage, and all the train of sequelae of chronic septic absorption result from unduly prolonged expectant treatment in such cases, and the difficulties and dangers of operation in the chronic stage are greatly multiplied. I believe that drainage should be instituted in all peripherally situated abscesses that do not present unmistakable evidence of healing during a period of almost two months of conservative or expectant treatment. Treatment with arsphenamine is indicated in all cases in which spirochetes are found in the sputum.

Chronic abscesses presenting an epithelialized cavity with multiple bronchial fistulas require wide open drainage and cautery to destroy the epithelial lining; some eventually require further plastic surgical measures.

Cases of multiple abscess are the most difficult of all. In my experience, cautery lobectomy is the most effective.

In bronchiectasis, compression therapy by phrenico-exeresis, pneumothorax collapse and thoracoplasty, should in my opinion be given first consideration. If such treatment is carried out early in unilateral cases of the peripherally localized saccular type such as can be differentiated by the contrast mediums, improvement, approximating a cure may, I believe, be expected in the majority of cases. Later, lobectomy can be performed with relatively much less risk than primary lobectomy in patients not sufficiently benefited. The marked and extensive fibrosis that results from the thoracoplasty, if not curative, will greatly facilitate the closure of the bronchial stump following either eradication by cautery or lobectomy.

DR JOHN L. YATES, Milwaukee, Wis. I shall consider the problems of intrapulmonary suppuration from a biologic aspect. Infections in and on bronchopulmonary structures are inevitably so frequent as to be virtually constant. Insusceptibility or susceptibility to infection, whatever the type of the micro-organism, recoverability or irrecoverability from infection after it is established, healing or failure of healing of lesions are traceable to strength or weakness of the powers of resistance, defense and repair. Correct definitions of these interlocking processes which control our destinies are imperative, because they are the foundation of therapy.

Resistance is provided by responses of fixed tissue cells adjacent to infection, reinforced by the cellular and noncellular elements delivered in the blood. Adequate resistance promptly suppresses invading micro-organisms without recognized signs or symptoms, and there is insusceptibility. Degrees of inadequacy of resistance impose corresponding grades of susceptibility.

Defense is developed after infections become established through the responses of fixed tissue cells within the local lesion strengthened by the cellular and noncellular elements delivered in the blood. Adequate defense promotes undelayed recovery with the least destruction of tissue. Inadequate defense intensifies and prolongs immediate disabilities, and destruction of the tissue is correspondingly greater.

Repair begins with the destruction of tissue and is continued until healing is complete, until obstructed by cicatrices and relative ischemia or until terminated at death. Repair consists of the responses of fixed tissue cells sup-

head and chest of the patient inclined downward. Postural drainage, in this sense, at the time of operation will aid in the immediate elimination of a majority of the fluid pus escaping from cavities.

This action of cough may likewise be the explanation of the manner in which vomitus and material from the buccal cavity reaches the alveolar spaces. Aspiration probably carries the material into the trachea and larger bronchi, but it is difficult to conceive that aspiration alone could



Figure 9



Figure 10

Fig 9 (cat 13) —Taken after injection, through a tracheotomy tube, of thick tenacious sputum, which had been injected with iodized oil. The masses are shown fairly intact.

Fig 10 (cat 13) —Taken shortly after figure 9 and immediately after cough with closure of the tracheotomy tube. No great change in the position nor spread of the injected masses of sputum is shown.

take the material as far as the alveoli, where it would have to come to rest in order to produce postoperative pulmonary infection. It appears far more likely that cough expels most of the fluid material after it has been aspirated into the trachea and larger bronchi, but forces some of it into the alveolar spaces.

When suitable paralysis of the diaphragm and measures to improve the quality of the blood are used as introductory procedures in combating broncho-pulmonary inflammation that does not subside spontaneously, they alone may promote healing. If they fail, subsequent intervention is less hazardous and often less extensive operations are required. If the paralysis be made transient, from three days to three months according to the method employed ultimate recovery is without disability. If recovery of motion of the diaphragm proves to be disadvantageous and a quiescent process is reactivated, a permanent paralysis may be required.

One fact, not as yet accepted, has been established. Collapse of the lung caused by the abolition of intrapleural negative pressures and pulmonary compression produced by pressures exceeding that of the atmosphere, not only impose a restriction of blood supply to the lung, but also increase cardiac labor. Relative anemia reduces resistance, defense and repair. Excess cardiac effort narrows the margin of safety. Collapse is rarely needed and is attained by complete resections of all ribs. Compression is seldom justified.

DR. KENNON DUNHAM, Cincinnati. The symposium has been much more stimulating to an internist than I imagine it might be even to a surgeon. Nothing has been more striking than the experiments of Dr. Crowe, by which he placed infectious material from the teeth and the sinuses in the bronchi and produced abscess of the lung.

It is common for clinicians to note bronchiectasis, chronic bronchitis, bronchopneumonia and even abscess following sinusitis.

The close relation of the upper and lower air passages has been shown by a recent study of 700 patients sent to the Diagnostic Center of the United States Veterans Bureau in Cincinnati, and which soon will be presented by Dr. Skavlem and me.

The condition in the 700 patients had previously been diagnosed as some chronic disease of the lungs. Tuberculosis was the most common cause but 164 cases of chronic nontuberculous infections of the lung were reviewed in the series and 128, or 79.29 per cent showed infection in the upper respiratory tract. Influenza, gas exposure and lesions of the heart accounted for most of the remaining 20 per cent.

Chronic infection of the ear should always suggest chronic sinusitis and the necessary examination should follow.

It is difficult to interest rhinologists in chronic sinusitis which does not cause symptoms in the head. Such lesions cause serious infections of the lungs. This society needs specialists in diseases of the nose and throat who will study and work with us, men who are studying the whole respiratory tract. Dr. Mullen, formerly of Colorado Springs now of Cleveland is such a man. He has done excellent research work along this line. He has proved that India ink can be carried from the antrum to the lungs and that the lymph nodes at the root of the lung are infected. He has not proved this transmission to be wholly through the lymph stream.

Infection from the teeth and sinuses can be directly aspirated into the bronchi. It is well that our surgeons are doing much to protect this route against infection.

The blood may also be infected pass to the right side of the heart and directly to the lungs, where the capillaries slow down the circulation and the white blood cells get their opportunity to attack the infection.

The system is better protected through the lymphatic stream.

Here the lymph chains act as natural barriers. These may be overpowered and the infection may reach the general circulation. Because the cervical chain



## ABSTRACT OF DISCUSSION

DR EVARTS A GRAHAM, St Louis I think all these fundamental considerations such as cough that have been taken up from time to time before this association are of the utmost importance, because any fundamental observation, of course, is of much more value than merely detailed observations relating to particular features of particular subjects. A number of points in Dr Archibald's paper interested me greatly. One point of practical importance that has come up in my own experience concerns the question of roentgen-ray interpretation after the use of iodized oil. I feel that since iodized oil is now, apparently, an accepted agent in the diagnosis of pulmonary conditions, the possibility of its having been used must always be considered in the roentgen-ray interpretation of films of the chest. What I mean more particularly is this. Recently I had a patient with pulmonary suppuration in whom iodized oil was introduced, pulmonary suppuration was confined to one lobe. Two months after the introduction of the iodized oil, the other lung on roentgen-ray examination seemed to be studded with extensive tuberculosis. That is to say, the plate mimicked accurately an extensive tuberculosis involving both lungs. As a matter of fact, the man was perfectly well at that time, and did not have any symptoms, not even cough. What evidently happened was that the iodized oil was scattered through both lungs, probably by coughing, as Archibald brings out. Unless the physician knew that iodized oil had been injected, if he had merely seen the plate, he would have been tempted to make the diagnosis of extensive tuberculosis in a person who was not at all tuberculous.

There are other dangers of cough which Dr Archibald did not mention. These are of practical danger to us as surgeons. I have seen an abscess of the lung rupture spontaneously during the course of operation under local anesthesia, as a result of violent coughing. Several times I have also seen pleural adhesions torn as a result of violent coughing. Several times, after suturing a lung to the wall of the chest in cases of pulmonary suppuration I have had the unpleasant experience of having these sutures torn away as a result of coughing during the next two or three days. Because this has happened to me, I have made it a rule to attempt to abolish the cough reflex as much as possible during the time in which I am attempting to create pleural adhesions. For that reason, it has been my practice to keep the patient under the influence of morphine for a period of days in order to diminish the cough as much as possible and thus to avoid tearing the adhesions I am trying to create.

Two other points that interested me concern the origin of the cough reflex and the spontaneous disappearance of cough reflex. First, in the series of experiments reported on abscess of the lung in dogs, Dr Allen found that for some reason some of the dogs coughed and others did not, regardless apparently of the location of the abscesses. Why some dogs coughed considerably during the whole progress of the abscess and other dogs seemed not to cough cannot be explained at present. In cases of bronchial fistula recently established, I have noted repeatedly (and this observation has been made by many others, for I have heard Dr Lihenthal speak of it a number of times) that the cough reflex from a bronchus of even considerable size will disappear over a period of time. I have made observations on a considerable number of patients. Soon after the establishment of the fistula, there will be an active cough reflex which can be produced easily by probing of the fistula. After possibly a couple of months or so, this cough reflex may have entirely disappeared, so that one can do almost anything inside of

localized acute pulmonary inflation with a foreign body, but I have not observed this type of disturbance in other than cases in which a foreign body was present. More commonly, irrespective of the cause, there are physical signs indicating partial or complete collapse of that part of the lung supplied by the occluded air passage. Roentgen-ray examination may afford such direct evidence as the shadow of a foreign body, but indirect indications of bronchial obstruction are more often obtainable and consist of changes which may be interpreted as due to pulmonary inflation or to collapse of parts of the lung supplied by the affected bronchus. Occlusion of a primary bronchus or one of its branches is so commonly associated with significant physical and roentgen-ray symptoms that their absence is to be regarded as evidence against bronchostenosis affecting these regions. Experience, however, is not sufficient at present to justify the belief that occlusion of the larger bronchi can with certainty in all cases be excluded by these means, and disturbances of the smaller bronchial branches fail to give significant symptoms. It seems desirable, therefore, that practically all patients with localized suppurative lesions be examined by bronchoscopy.

Dr Kernan is to be congratulated on his favorable results with bronchoscopic treatment. His twenty-nine "cures," 42 per cent, in sixty-eight patients on whom three or more bronchoscopies were performed is strikingly in favor of this method on comparison with my series of 106 cases in which the patients were treated by rest and postural drainage and in which twenty-four, or 22.6 per cent, recovered when the duration of the illness was eight weeks or less. I should like to ask Dr Kernan what his bronchoscopic procedure was.

DR. LILIENTHAL. I think Dr Lord was mistaken. Instead of "bronchoscopy," as he understood it, the word was "bronchostomy."

DR. ROBERT MILLER, Baltimore. May I say a word about the papers of Dr Allen and Dr Crowe? These two papers represent excellent laboratory work. In relation to that of Dr Crowe, I found myself working on the same subject three years ago, and consequently am more or less familiar with its development. All of us went through a phase of doubt as to whether one could produce an abscess in the lung of a dog. Some of us were beginning seriously to consider the dog immune from this condition. I was much surprised at the extreme type of experiment.

Our experience was that if one partially resects two ribs in a dog and exposes the lung, deliberately cauterizes an area straight into the parenchyma of the lung, burns it out, devitalizes it, then places in the cavity a rough metallic foreign body large enough to irritate the walls of the cavity and closes both the wound in the lung and in the wall of the chest without drainage, healing by first intention always follows. With the wound firmly healed we tried to inject cultures of hemolytic streptococci. We localized the foreign body and knew we were placing virulent streptococci together with a foreign body in a closed cavity. This inevitably means an abscess in the human body but not in a single one of these dogs could we produce an abscess of the lung. Curiously enough, even under the conditions described if the dog was allowed to live, the foreign body was sometimes extruded from the lung and lay in the pleural cavity. Until one has tried to produce an abscess of the lung in the dog it is difficult to realize how much work this paper by Dr Crowe and that by Dr Allen represents.

I was interested in the remarks of Dr Hedblom regarding the treatment in early cases of bronchiectasis in the lower lobe. We have encountered several cases of this sort in Baltimore recently. The patients have all come from the internists with a diagnosis of either early bronchiectasis, small abscess, or the

The physical means to control the useless cough and also to make the useful cough less painful and diminishing its intensity consist in bandaging or, rather, encircling the thorax with wide strips of Lilienthal's elastikon. Even if the encircling band is tight, its elasticity will permit the patient to breathe with relative comfort. The importance of thus restricting cough and respiratory movements at the same time is, of course, of obvious advantage in thoracoplastic cases. Under physical means of controlling useless cough I must also mention the importance of urging the patient to lie on his affected side, even during sleep. He will thereby compress the affected lung in a measure, diminish the respiratory movements and, *ipso facto*, lessen the desire to cough. The posture treatment can be aided materially by the use of little pillows placed so as to enable the patient to maintain the most desired position with the greatest ease and comfort. When the cough, which I designated before as a nervous or habit cough, cannot be controlled by discipline alone, it is well to suggest to the patient that he make a sudden inspiratory effort, that is to say, inhale quickly and shortly when he thinks he must cough. This method of treating habit cough is often effective.

My own method of reducing the number of respirations and limiting them to the diaphragm during the waking hours, I believe, may be justly considered as another physical means to control useless cough. I explained this method in full at the last Washington meeting of this association in my address on the subject of "Medical Care of Thoracoplastic Cases."

The last method of controlling cough is by medical means. These are too numerous to mention here, so I will limit myself to speaking merely of a few. Plain water taken in small sips will help to control the merely irritating cough. Sodium chloride in rather large quantities taken with food will help when the expectoration is so tenacious as to make the ejection painful. The various alkaloids of opium are often resorted to in combination with expectorants, such as ammonium chloride, ammonium carbonate, balsams of peru and tolu, licorice, cherry laurel water and glycerine. However, the most efficient anti-cough remedy in my experience is heroin, and I mention this not without a feeling of regret. It has been my privilege to serve in three military departments of this country: the regular army, the U. S. Public Health Service and the U. S. Veterans' Bureau. In none of them is the use of heroin allowed, simply because it is thought that the dispensing of heroin might lead to drug addiction. I am willing to confess that I have prescribed it from the time when it was first put on the market, and I cannot recall a single case in which addiction to heroin developed, perhaps because I was exceedingly careful. The largest dose I have ever prescribed was  $\frac{1}{12}$  grain (0.005 Gm.) every four to six hours, with the direction to give less as cough subsides, and I have never written a prescription without the injunction to the druggist "Ne repetatur sine ordine." When heroin cannot be prescribed, codeine is the best substitute. Of course, surgeons have a right to resort to hypodermic injections of morphine after a thoracic operation to allay the cough, but I feel sure that their experience also is that such injections to control painful cough and to diminish hurtful succussions lead to morphinomania only in the rarest instances, if ever.

I present these suggestions, not in the spirit of criticism of Dr. Archibald's valuable contribution, but as a possible help in the management of the cough.

DR. FREDERICK T. LORD, Boston. Dr. Archibald's paper brings up for discussion an important and often perplexing problem as to the best treatment

not to be accurate, because in the case of the lung there is a constant inside pressure of 15 pounds (68 Kg) to the square inch through the air passages, but, provided there is no obstruction in the air passages, this pressure remains the same, whether the lung is expanded, collapsed or compressed and therefore this factor need not be considered. We must therefore come to the conclusion that the greatest amount of blood is found in the expanded lung less in the collapsed lung and least in the compressed lung.

In reference to Dr Eggers' paper, his observation was exceedingly interesting, and the words selective action forcibly bring out Dr Eggers' meaning. Of course, the pressure within the thorax cannot select one part more than another, there will be an equal amount of pressure on all parts of the lung, the reason why there is an effect on the diseased part is that the pressure is more effective there. That particular part, previous to the pneumothorax, is edematous, and there is some destruction of tissue. The lung in that particular portion has lost its elasticity, consequently, the pressure on that part will be more effective than the pressure on the normal part of the lung. If, on the other hand, the same portion had already undergone cicatrization, the supposedly selective action would not be observed.

DR WILLIAM LERCHE, St Paul, Minn. I should like to mention two cases of foreign bodies in the bronchi with results analogous to those that Dr Graham had in his experiments, namely, multiple abscesses. In one of the cases a pimento, in the other, bits of peanut, had become lodged in the bronchi.

DR. E. A. GRAHAM, St Louis. I shall try to be brief, although there is a temptation to speak a good deal on this long list of papers.

I was glad that Dr Lilienthal made the statement which coincides entirely with my own opinion about these cases, namely, that at the present time there cannot be any standardization of treatment in cases of pulmonary suppuration. Furthermore, results which are important in a symposium like this are of necessity applicable only to the type of cases which the author is thinking about when he makes his report. For example, I know that I do not operate in certain cases of suppuration of the lung when others do. I know equally well that I operate in certain types of cases when other surgeons perhaps would not operate.

Therefore, when we are speaking of pulmonary suppuration, I think each of us has a certain reservation in mind which it is often difficult to express and describe when one deals with patients treated by a certain method and other patients treated by other methods.

If all cases of pulmonary suppuration without regard to type or distinction are placed in one large group, the proposition must be faced at once that no matter what form of treatment is given or whether or not any treatment is given, the mortality rate will be high. Why is that true? One reason is that at least in the experience of Singer and myself, based on more than 300 cases of pulmonary suppuration, 10 per cent of the cases have been associated with carcinoma of the lung, it has not always been primary carcinoma but it has at least been malignant disease of the lung.

With the present unsatisfactory method of treating patients who have malignant diseases of the lung 10 per cent, if the series is large enough, will die no matter what is done for them. There is also a large percentage of patients with pulmonary suppuration, at least in our experience, who have cerebral embolism or cerebral suppuration or meningitis. Many of these patients have come to us with these features already developed.

# INFECTIONS OF THE LYMPH NODES OF THE BRONCHIAL TREE

WILLIAM LERCHE, M D

ST PAUL

The tracheobronchial lymph nodes, as described by Sukiennikow,<sup>1</sup> were briefly outlined by me in a recent paper.<sup>2</sup> The bronchopulmonary nodes, also described by Sukiennikow, are found mostly at the angle of division of the larger bronchi (fig 1). Miller<sup>3</sup> stated that the bronchopulmonary nodes and lymph follicles are rarely found beyond the third division of the main stem bronchi, but that lymphoid tissue aggregated in masses of variable sizes are found throughout the lung. The situation of these masses may be peribronchial, periarterial, perivenous or

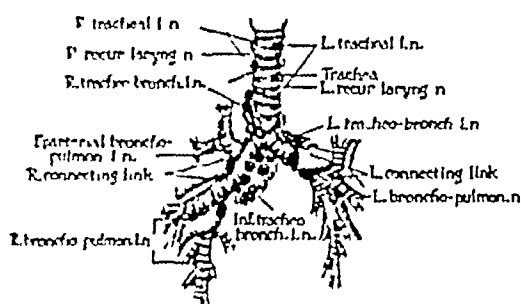


Fig 1—The tracheobronchial and bronchopulmonary lymph nodes (Sukiennikow)

subpleural. According to Miller, there are five locations at which lymphoid tissue is particularly found: (1) where the radicles of the pulmonary vein arise from the pleura, (2) where veins arising from the distal end of ductuli alveolares join venous trunks situated on the periphery of the primary lobule (anatomic unit), (3) where veins arising near the place at which bronchi or bronchioli divide, join larger venous trunks which may be situated in septums of connective tissue, (4) at the distal end of the ductuli alveolares, and (5) at the place where

1 Sukiennikow, W. Topographische Anatomie der bronchialen und trachealen Lymph drüsen, Berl klin Wchnschr, 1903, p 316

2 Lerche, William. Infected Mediastinal Lymph Nodes as a Source of Mediastinitis, Arch Surg 14 285 (Jan) 1927

3 Miller, W S. Studies on Tuberculous Infection. III. The Lymphatics and Lymph Flow in the Human Lung. Am Rev Tuberc 3 193 1919

Despite the fact that this type of operation has been reserved for the most refractory cases, essentially the cases of chronic suppuration that continue for periods of years, and despite the fact that many have been cases of multiple abscess and similar conditions, it seems to me that our results have been reasonably satisfactory. For example, in this series of forty-five cases, there have been three deaths which I would ascribe directly to the operation. One was the case of hemorrhage to which I referred. Two were cases of cerebral embolism, presumably, air embolism occurring during the cauterization, which resulted in instant death. In addition to that, however, there are four other patients who died while still in the hospital, I am willing to say that they died as a result of operation, but death occurred from four to ten weeks after the cauterization. They include (1) one death from acute cardiac dilatation sixteen days after cauterization, (2) one death from pyemia, in this case, abscesses were scattered throughout the body, if we had recognized that, we would not have kept on working at the lung, (3) two deaths from cerebral suppurative complications—meningitis in both cases.

Thus, seven patients have died in the hospital following this procedure, a mortality of 15 per cent. In addition, during the three years that we have been carrying out this procedure, we have learned that five other patients are dead. These patients died of various conditions not attributable to the operation of cauterization pneumectomy. Two died during attempts made elsewhere to close bronchial fistulas. Two other patients were said to have died of pneumonia. Possibly they had a recurrence of pulmonary suppuration, they died from a year to a year and a half after operation. In all, 25 per cent of these patients are dead, but 43 per cent are well, entire healing has occurred and bronchial fistulas or other conditions have not resulted. An additional 15 per cent of patients are free from symptoms and are back at their usual duties. Some of them are laborers who perform heavy labor, others are housewives, but the latter have bronchial fistulas. There are an additional 13 per cent on whom operation has been performed within the last six months who are well and free from symptoms, but I do not know yet what the results will be. There is one case, or 2 per cent, concerning which I have not been able to get a follow-up report. Twenty-five per cent of the patients are dead, but 73 per cent are known to be free from symptoms at the present time, most of whom are back at work earning their living and carrying on their usual occupations. Of the total number of forty-five cases in my own experience, there was only one death from hemorrhage.

Now a word or two about bronchial fistulas. I have a feeling that has been expressed once or twice at this symposium that bronchial fistulas had better be let alone. Some of the speakers do not agree, but in my own experience in the majority of instances, after bronchial fistulas have ceased to be of use they heal spontaneously. I think too much tinkering is done with them. I think the operation of closure of the bronchial fistulas is serious. In my cases fatal air embolism has occurred, which is as tragic as any death that could result from any operation of any type and still more tragic because one does not expect it.

I have been astonished to listen to the discussion on pneumothorax because I had thought that if there was one treatment which had been found to be effective in certain cases of suppuration of the lung, it was pneumothorax. It has been amazing to hear a controversial discussion on that subject. I did not bring our statistics along, but Singer and I have seen many patients with cases of acute abscess of the lung recover after the performance of

but communicate freely with each other. On the other hand, according to Miller, valves prevent the passage of any injection mass from the pleural lymphatics into the deep lymphatics of the lung, since the valves in the connecting vessels between the pleural and the deep lymphatics point toward the pleura. Therefore, when the normal drainage of the deep lymphatics of the lung toward the hilum is prevented, the flow may be into the pleural lymphatics. Miller suggested "that this arrangement of the valves, probably explains why tubercles may be found in the pleura and not in the deeper part of the lung." It also probably explains the formation of acute nontuberculous abscess in this locality. Valves pointing toward the hilum have been found in the main trunks draining the pleural lymphatics and also in the lymphatics about the pulmonary veins near the hilum. The lymph from the lungs, the bronchi and the lower part of the trachea and its bifurcation, as well as from the larger part of the pleura, is received by the tracheobronchial nodes. The lymphatics from the pleura of the inferior half of the lower lobe according to Cunningham, pass through the ligamentum pulmonale and drain into the preaortic lymph nodes.

There are two routes by which micro-organisms can enter the area drained by the tracheobronchial nodes. 1 They may be carried into the lower respiratory passages by inhalation, penetrate the epithelial lining and be conveyed to the tracheobronchial nodes by the lymphatics. Rogers<sup>6</sup> observed that seven days after guinea-pigs had inhaled tubercle bacilli, by being sprayed with an emulsion of tuberculous sputum, tubercles were macroscopically visible in the lungs, and the tracheobronchial nodes were distinctly enlarged. 2 The micro-organism may be carried by the blood stream, and, after passing through the walls of the vessel, may gain the lymphatic system and be conveyed to the tracheobronchial nodes. Krause<sup>7</sup> found that

After subcutaneous (right groin) infection of guinea-pigs with massive doses of tubercle bacilli they were found in the lung and tracheobronchial nodes at four days. At any given time during the period from four to twenty-six days after infection there are more bacilli in the tracheobronchial lymph nodes than in both lungs.

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5 Cunningham, R. S. On the Development of the Lymphatics in the Lungs of the Pig, *Anat. Record* **9** 69, 1915.

6 Rogers, J. B. Further Observations on the Artificial Tuberculous Infection of Guinea Pigs Through the Respiratory Route, *Am. Rev. Tuberc.* **3** 750, 1920.

7 Krause, A. K. Tuberculosis in the Guinea Pig After Subcutaneous Infection, with Particular Reference to the Tracheo-Bronchial Lymph Nodes, *Am. Rev. Tuberc.* **4** 135, 1920-1921.

the next meeting of the American Surgical Association in which I opened a tuberculous cavity and tried to make the resulting stoma permanent, it was impossible to do so, and the stoma closed. The patient still has tuberculosis.

Now as to the air embolism, if Dr. Graham will work with the patient's head lower than his heels, he probably will not get air embolisms.

DR A. O. WILENSKY, New York. I have been much interested in Dr. Crowe's experimental work, because a number of years ago I tried to make an abscess of the lung, and the method I used was the following. I performed experiments on both dogs and cats. I took a bronchoscope and passed it into the trachea. As at that time there were many cases of abscess of the lung, there was no difficulty in getting the contents of the abscesses, and I injected the latter directly into the trachea. Either nothing happened or the dog was sick for a day or two and then gradually recovered, ultimately an abscess did not form. I think the dose of material was given so suddenly that the reflexes of the animal were sufficient to expel the mass of material injected. I am interested in Crowe's work for this reason, when a focus of suppuration is established in anatomic relation with the air passages, as by his method, the dose of infection is brought down constantly in small quantities, and I think that is the reason why the infection materializes into an abscess of the lung. It is interesting to note that so many of the children in whom Dr. Graham found sinus disease recovered after the condition of the sinuses was cleared up.



Among its several functions is the major one of limiting the spread of infections, and in no infection is this office so manifest and so well performed as in tuberculosis. Whether tubercle bacilli are inhaled or ingested, practically every natural infection begins at that moment when they shall have passed the mucosal epithelium and have gained the submucosa. There, between the cells of a bodily structure, they are always, first within the province of the lymphatic system, and all that are conveyed further will, within a microscopic distance be carried into lymphatic vessels and proceed by these for variable distances. At countless places they will meet with intercalated collections of lymphoid cells that range from the minutest aggregations to large lymph nodes. It is impossible to escape the idea that one of the resisting functions of allergy lies in the latter's ability to fix bacilli promptly where they settle and thus impede or prevent their further distribution. Lymphoid masses will act similarly, though in another way. In every instance in which infection is established we must believe that both the lymphatic system and allergy are contributing their part to the sum total of resistance.

When micro-organisms settle in a lymphoid mass or in a lymph node in the lung, they may (1) become destroyed in situ or remain latent, (2) inflammatory reaction may take place followed by healing, with or without deposits of calcareous matter, (3) suppuration may take place, and the node involved ulcerate into a bronchus, or (4) into the parenchyma of the lung and give rise to an abscess of the lung.

#### REPORT OF CASES

CASE 1.—A man, aged 33, had had measles and whooping cough in childhood, otherwise he had been well, although he had never been robust. Two months before he came to me for examination, he had noticed a slight pain a little above the right nipple and a slight cough accompanied by a scant but offensive expectoration of purulent material. The symptoms soon subsided. Twelve days later, he had a severe pain just above the right nipple, at the same time, he had an attack of coughing with the sudden expulsion of large quantities of extremely offensive smelling material. The patient had been working up to the time of the rupture of the abscess, which happened while he was being jolted in riding in an automobile over a railway crossing. He was then in bed for a while. According to his statement, he did not have fever throughout this sickness. The cough and expectoration gradually became less, and the odor disappeared. The lungs were normal, except for a few râles in the right lung. Results of the examinations of the sputum for tuberculosis were negative. Roentgenograms showed that the right lung had not cleared up in the triangular area (*a a a*, fig 3) that probably had been the seat of the abscess. The shadow, *b*, in the roentgenograms proved to be two concretions probably expelled from the cavity of the abscess into a bronchus. The patient was advised to have the concretions removed by bronchoscopy, but he coughed up the larger one without aid a few hours later. Bronchoscopy was postponed at his request. Two weeks later, he coughed up the smaller stone. The cough and expectoration gradually ceased, and the patient's health has been good. The suppuration probably started in the tissue surrounding the concretions in the bronchopulmonary nodes. Whether the micro-organisms had been latent or of recent arrival, they had apparently been of low virulence.

the trachea unaccounted for. The sum total of the contraction of all the muscles involved results in a sudden diminution of intrathoracic capacity, with a corresponding concentric rise in intrathoracic pressure. The latter is readily demonstrable with a pneumothorax manometer and needle inserted into the thorax during cough. And, furthermore, the height of the manometer reading during cough will be the same regardless of which portion of the chest cavity is tapped, thus demonstrating the existence of a uniform concentric rise in pressure from all sides. Hence, a uniform pressure is exerted on all portions of the lungs. An outlet for this increase in pressure is sought and is found in the sudden escape of air from the lungs through the trachea, larynx and buccal cavity. This sudden expulsion of air is recognized as the common manifestation of cough.

Any foreign substance in the tracheobronchial tree may be capable of stimulating the cough reflex. However, it has been demonstrated repeatedly that a tolerance to the excitation is rapidly obtained—in a matter of minutes—whereby the reflex is lessened and often temporarily entirely lost. On the other hand, all portions of the pulmonary tree are not equally excitable. Jackson<sup>2</sup> concluded from bronchoscopic observations that the finer subdivisions of the tracheobronchial tree, together with the alveoli, show decidedly less cough production from instrumental contact than the larger bronchi, while Reinberg,<sup>3</sup> working with the fluoroscope, found that secretions in the peripheral bronchial tree (filled through a bronchial fistula) did not produce cough in bronchi of the fifth, fourth or third order, cough being produced only when the second or first order or the trachea is filled. While operating under local anesthesia on a patient with a long standing pulmonary abscess which had recently been exposed by thoracotomy, we observed that cough was readily initiated when the larger communicating bronchi were probed. In a case of pulmonary abscess, opened through a large window in the chest, in the base of which there opened a number of bronchi and bronchioles, we made the observation that cough was readily initiated when a probe was inserted into one of the large bronchi, while a similar procedure was without effect in the case of the bronchioles.

Moreover, the act of coughing, although itself primarily a forced expiratory effort, is immediately preceded or followed by a markedly increased inspiration. This becomes most evident during a so-called spasm of coughing, when one observes a rapid succession of deep inspiratory and increased expiratory efforts.

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2 Jackson, C. Cough. Bronchoscopic Observations on the Cough Reflex, *J. A. M. A.* **79** 1399 (Oct. 21) 1922.

3 Reinberg, S. A. Roentgen-Ray Studies on the Physiology and Pathology of the Tracheo-Bronchial Tree, *Brit. J. Radiol.* **30** 451 (Dec.) 1925.

CASE 2—A man, aged 23, had had whooping cough at the age of 3 years. Shortly after this attack, he aspirated a brass cuff link. Since this accident he had had a cough, at first it was dry, but it gradually became purulent, and the sputum had a fetid odor. He had often had vomiting spells since the accident. The patient was referred to me at the age of 14. Roentgenograms revealed the cuff link in the right bronchus (fig 4). He had a right bronchiectasis and clubbing of the fingers. Bronchoscopic examination revealed a stricture of the right bronchus a little below the origin of the upper lobe bronchus. Granulation tissue and a great deal of pus were seen. The cuff link was removed. Some time later the patient returned, and he was advised to try bronchial lavage and treatment through the bronchoscope, but the advice was not accepted. At the age of 23, he again returned and wanted something done for the cough and for the foul expectoration. The sputum amounted to 300 cc in twenty-four hours,

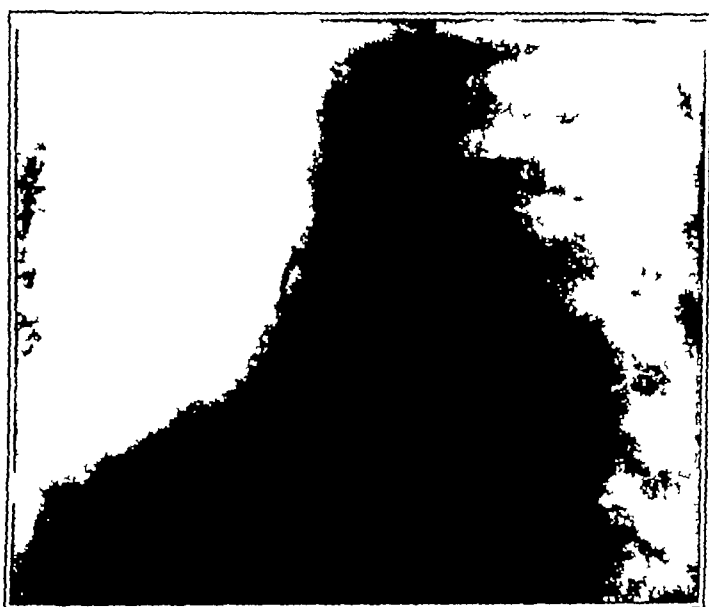


Fig 4 (case 2) —Roentgenogram showing the cuff-link in the right bronchus

examinations for tubercle bacilli were negative. The urine was normal. Roentgenograms after injection of iodized oil 40 per cent showed bronchiectasis of the middle and lower lobes of the right lung (fig 5). I intended to perform a graded thoracoplasty, but the patient developed cerebral symptoms and died of abscess of the brain.

Necropsy had to be limited to the right lung (fig 6). The lower and middle lobes were pink with darker areas of red. The upper lobe had the pigmented appearance usually found in the lungs of the adult city dweller. The right tracheobronchial groups of lymph nodes consisted of a firm reddish mass measuring 2.5 by 4.5 cm. The inferior group was similar in color and consistency and measured 2.5 by 5.5 cm. The groups of nodes at the angles of the division of the bronchi to the middle and to the lower lobes were large and firm, one measuring 3 by 1.75 cm. Nodes 2, 3 and 4 encroached on the vessels. The necks

16 Pancoast, H. K., Dunham, K., and Baetjer, F. H. Clinical and X Ray Findings in the Chest of Normal Children, *Am Rev Tuberc* 6:331, 1922

lobe of a tuberculous pulmonary cavity, and noted that the material dropped to the bottom of the cavity. With three successive coughs it was spread into the middle lobe, then transported to the lower lobe of the other side and finally coughed up. This important observation affords a visual demonstration of the spreading action of cough, and suggests the mechanism of the production of bronchial embolism. Ballon noted a similar phenomenon when iodized oil had been injected into the bronchiectatic cavities of a patient. After a few minutes cough was seen to empty the cavities and disseminate the oil widely throughout the pulmonary field. Ameuille points out that this illustrates how aspirated infectious material may be scattered by cough to all portions of the lung.

Still another mode may be suggested whereby, under certain conditions, the expiratory effort itself may be the means of spreading or forcing material deeper into the pulmonary tree rather than expelling it. For example, one may assume that there is a block, such as might be produced by a plug of mucus or a bronchiolar spasm, in a proximal bronchus. Then one may imagine that material distal to the block is forced toward it by the expiratory forces during cough, is unable to pass the block and then, immediately after cough, is carried on the rebound distally beyond its original depth of penetration either toward the original alveolus or now into new areas. Thus in figure 2 it is assumed that a block exists at *A*, then the material *B* approaches *A* during cough and immediately afterward is carried distally toward or into the alveolus *C*, or possibly into other alveoli distal to the block such as *D* or *E*.

However, regardless of the exact mechanism whereby the result is obtained, it has, as noted previously been repeatedly observed clinically that cough may be the means of spreading material in the tracheobronchial tree. The following experiments are presented with the view of demonstrating the truth of this assumption.

#### EXPERIMENTAL METHOD

In order to be able to visualize and secure permanent records of the action of cough on material in the tracheobronchial tree we used a substance which would cast a shadow by roentgen ray. The iodized oil was selected because of its excellent roentgenographic properties, the ease of its introduction, and the possibility of incorporating it with other substances. Three sets of experiments were planned: one with oil alone, another with equal parts of the oil and thick sputum (obtained from a patient with bronchiectasis) which were thoroughly mixed by being drawn back and forth repeatedly through a narrow mouthed syringe until a perfect emulsion was obtained of a fluidity approximately equal to the oil alone, and another with thick tenacious mucus (a

5 Ballon D. H. Lipiodol in the Diagnosis of Bronchopulmonary Lesions by the Bronchoscopic Method. Arch. Otolaryng. 3:403 (May) 1926.

of the bronchi to the middle and lower lobes were constricted, peribronchial fibrosis was marked at these points, and the bronchial walls were thick and fibrous. The nodes at the angle of division to the upper lobe were soft and anthracotic (fig 6). The difference in color between the upper lobe and the middle and lower lobes was striking. Microscopic examination of the nodes from the middle and lower lobes showed only a small amount of pigmentation, while the gross appearance of the nodes from the upper lobe was that of marked anthracosis.

Shingu<sup>17</sup> has shown that pigmentation is present in the lungs of human beings more than 23 days old. In the normal lung, some of the finer particles of carbon and other inhaled dust may enter the alveoli



Fig 7 (case 2)—Roentgenogram of the fresh specimen of the lung after injection with sodium bromide solution, and the various groups of nodes covered with lead foil corresponding exactly with their forms. The arrow points to the stricture caused by the cufflink. The right group of tracheobronchial nodes in the specimen was in close contact with the trachea and the right bronchus, with the lower pole overlapping the bronchus. The apparent separation is due to the angle at which the roentgenogram was accidentally taken.

and be carried by phagocytes through the alveolar wall to the lymphatics, which convey the dust-laden phagocytes to the tracheobronchial nodes. On their way thither, however, much of the dust is deposited in the tissues along the lymphatics, in the lymphoid masses and in the bronchopulmonary nodes. Pigments may be found in practically all the tissues

<sup>17</sup> Shingu, S. Ueber die Staubinhalation bei Kindern. *Virchows Arch f path Anat* 200 207, 1910.

placed on an inclined plane of 30 degrees, head up, so as to facilitate the flow of the oil into the finer bronchi. Cats were the experimental subjects in all instances but one, in which a dog was used.

In nearly all of our own series of cases the injection was made by the bronchoscopic method. All the injections were made by Dr David Ballou, of the department of otolaryngology in the Royal Victoria Hospital. We agree with his attitude that at least in the first injection of the oil the bronchoscopic method should be used, for the reason that this is the only method which can yield a satisfactory and direct visual examination of the injected field. Reference should be made to Dr Ballou's papers for a full statement in this respect. Later injections may well be made by the indirect transglottic method, aided by proper posturing. The results of this method have been satisfactory when combined with the information afforded by the first bronchoscopic examination.

Preliminary experiments were then conducted in order to determine the rate at which iodized oil or the iodized oil-sputum emulsions flowed into the pulmonary tree under light general anesthesia. This was done by taking a series of roentgenograms at intervals of from two to three minutes, beginning immediately after injection. Four animals were used, two with the oil alone and two with the emulsion. The rate of flow in all instances was approximately the same. Thus, it was found that the larger bronchi were outlined in from two to four minutes, that from eight to ten minutes were required for good penetration of the finer bronchioles and that maximum penetration, as determined by the roentgen ray, took place in from twenty to twenty-five minutes. It is, of course, obvious that a true flowing action will not occur with masses of thick tenacious sputum, so that in experiments with this substance it was unnecessary to take into account the time element. Thus it was clear that if any "indrawing" action of cough were to be observed the cough should be induced as soon after the introduction of the material as possible and the roentgen ray record should be taken immediately. Therefore, the procedure was to introduce the material, stop anesthesia and take a control roentgenogram. By this time, about two minutes having passed, cough could be induced, following which another roentgenogram was taken all of which could be done in well under five minutes, and consequently before penetration of the finer bronchioles would normally have occurred. As soon as cough was obtained, narcosis was continued and this process could be repeated as often as desired so that one might watch the further action of subsequent coughs.

#### EXPERIMENTAL OBSERVATIONS

In the present article, we shall consider merely the direct action of cough on the material introduced into the tracheobronchial tree and shall purposely omit from discussion all secondary complications noted, such as pulmonary edema, pneumonia, massive collapse of the lung and the development of abscess of lung. We hope to publish these observations in the near future.

*Action of Cough on Iodized Oil or Iodized Oil-Sputum Emulsion.*—As similar results were obtained both with the oil alone and with the emulsion, they are considered under one head. Seventeen injections were made in this group two of which were unsuccessful because of

CASE 3—A girl, aged 19, had had measles at the age of 5. Since the attack she had had a cough and had expectorated a thick purulent material of a foul odor. The patient was well developed, the fingers and toes were clubbed. Examination of the chest revealed lagging in the base of the left lung, dullness in the left side below the fourth rib, bronchovesicular breathing on the left side below the second rib and in the right axilla, and moist, large râles over the left side of the chest on inspiration and especially on expiration. On bronchoscopic examination, purulent material was observed coming from both lungs and constriction of bronchial necks was noted. Roentgenograms showed heavy markings in both lungs, but especially at the divisions of the bronchi to the lobes on both sides, where pronounced fibrosis and calcified nodes were seen (fig 8). Points of calcification were seen toward the periphery of the lungs, probably indicating healed inflammatory processes in lymphoid masses. The diagnosis was bilateral bronchiectasis with abscesses following measles in childhood.

CASE 4—A girl, aged 24, complained of difficulty in breathing and a chronic cough with more or less purulent expectoration since she had had whooping cough at the age of 3, at the age of 21, she had had influenza. The amount of sputum varied, and at times it was relatively small, but she said that she had frequent "colds" with prompt increase of the purulent expectoration, there was no disagreeable odor to the expectorated material, and it was negative when examined for tubercle bacilli. She had a wheezy respiration and considerable dyspnea on exertion. The patient was of small stature, she had marked kyphosis and right scoliosis. The fingers were clubbed. The anterior wall of the chest was flat, expansion was limited, especially on the left side. Breath sounds came through better on the right than on the left side, the inspiration was more difficult on the left. There were many bubbling râles and squeals, especially on the left, pleural thickening on both sides, an area of dullness over the middorsal area and emphysema over the outer portions of the lungs. Roentgenograms showed fairly heavy markings throughout the lungs, particularly in the upper lobes, the bronchopulmonary nodes at the angle of division to the upper lobes and the tracheobronchial nodes were markedly enlarged, especially the left and inferior groups of the latter (fig 9). Bronchoscopic examination showed the trachea and left bronchus red and inflamed with an area of darker red to the left of the carina, purulent material was seen coming from both lungs. The diagnosis was bilateral bronchiectasis following whooping cough in childhood, with probable suppuration of nodes in the inferior tracheobronchial space. The attack of influenza three years previously may have given rise to the suppuration. I told the patient that the suppurative nodes might ulcerate through the tracheobronchial wall. A few weeks later, she wrote that she suddenly had coughed up pus that differed from the usual purulent sputum and that she felt better.

Bronchiectasis occurs in young children, and the majority of cases of bronchiectasis in adults that can be traced to childhood are sequelae to measles or whooping cough. Brauer<sup>20</sup> said

The statement that the majority of cases of bronchiectasis are congenital, is due to the fact that although in children inflammatory processes of the lung often occur as for example after measles, it is not always elicited in taking the history.

20 Brauer, L. Ueber Pathologie und Therapie der Bronchiectasien. *München med Wchnchr* 72:964, 1925.

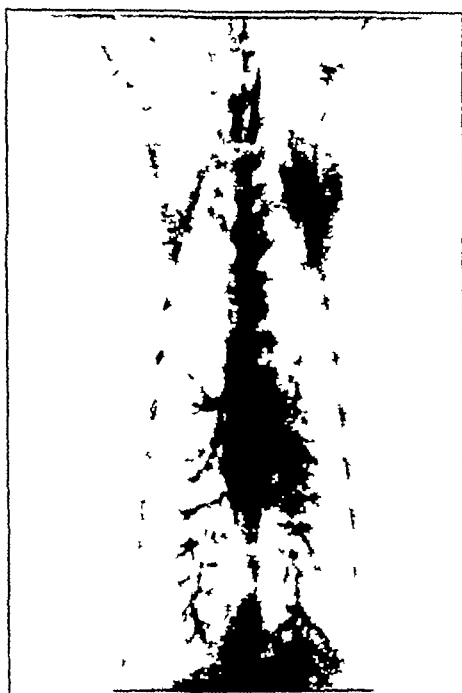


Figure 3

Fig 3 (cat 20)—Extent of penetration of iodized oil-sputum emulsion three minutes after injection without cough

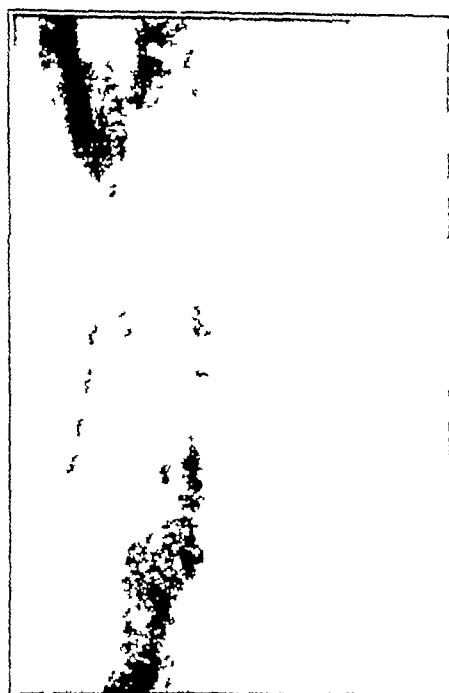


Figure 4

Fig 4 (cat 15)—Widespread penetration of iodized oil three minutes after injection and immediately after induced coughs without tracheal compression

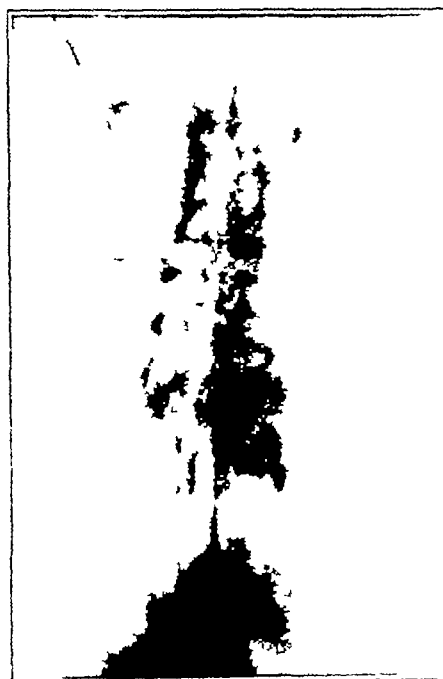


Fig 5 (cat 11)—Fine diffuse spread of iodized oil particles three minutes after injection and one minute after induced coughs without tracheal compression



in four, and tuberculosis in one. In all these cases, enlargement of the bronchopulmonary and tracheobronchial nodes were found. The size of the bronchopulmonary nodes ranged between that of a pea to that of a small walnut, but in most instances, they were the size of a hazelnut or a kidney bean. The tracheobronchial nodes varied in size from that of a pea to that of a small hen's egg. Thirteen of the twenty cases were complicated by bronchopneumonia, which accompanied whooping cough in nine of the cases. The average time from onset to death in the ten cases of whooping cough was about twenty-eight days.

In the majority of cases of infection of the bronchi or of the lungs, the micro-organism enters the lower respiratory tract by inhalation. After penetrating the epithelial lining, it reaches the submucosa and at once enters the lymphatics and begins its journey toward the tracheobronchial nodes, which it may reach unless intercepted by one of the interpolated lymphoid masses or nodes. With continued microbic invasion, the nodes enlarge and may ultimately become blocked, and as the lymphatic drainage fails, the micro-organism wanders through the lymphatic wall into the surrounding tissues, where inflammation ensues. The inflammatory process may subside and healing take place, or it may progress and become chronic, the enlarged nodes (by pressure) and the inflammation in the bronchial wall or in the peribronchial tissue thus furnishing two factors inductive to the development of bronchiectasis. As the inflammatory process spreads, it involves the musculature, the elastic tissue and the cartilages of the bronchial walls, and the surrounding tissues. With infective material stagnating in the obstructed bronchi, the pathologic picture of destruction in advanced bronchiectasis described in textbooks gradually develops. The rapidity with which lymph nodes increase in size is notable in one of the cases reported by Forgeron,<sup>1</sup> that of an infant, aged 3 months, who died a few days after the onset of influenza. At necropsy, congestion of the lower lobes with edema was found. Bronchopulmonary nodes formed masses the size of large hazelnuts, associated with periadenitis, the tracheobronchial nodes were seen in masses varying in size from that of a small kidney bean to that of a large almond. It seems probable that the congestion and the edema of the lower lobes in this case may have been caused by pressure on the vessels by the swollen bronchopulmonary nodes.

In case 4 in a paper recently published by me,<sup>2</sup> enlarged tuberculous eparterial nodes compressed the bronchus to the complete obliteration of its lumen, in case 3 in the same paper, the enlarged left tracheobronchial nodes (nontuberculous) caused pressure on the left main bronchus. In case 2 in the present article, the bronchopulmonary nodes at the angle of division of the middle and lower lobe bronchi caused pressure on the vessels, and the bronchial necks were fibrous and strictured. In

*Action of Cough on Tenacious Sputum Injected with Iodized Oil*—Six injections were made, all through a tracheotomy tube. The first two attempts were unsuccessful, as the injected material blocked the trachea and the animals died of asphyxiation. It was then found that if the mass was injected at the beginning of an inspiratory effort it would be carried to a point just beyond the bifurcation, and hence at least unilateral respiration might continue. Thus, in four instances we were able to note the effect of induced cough plus tracheal compression on thick tenacious sputum. It was observed that although the mass might be forced slightly into the larger bronchi it was not broken up nor forced into the finer bronchioles or alveoli. Thus, the material came to rest in a sensitive area in which it might subsequently induce normal reflex cough. This was found to take place, and subsequent roentgenograms showed that the material was soon expelled. Figure 9 shows the masses fairly intact, and in figure 10, taken after cough with tracheal compression, no great change is noted, while in figure 11, taken thirty minutes later, no foreign shadow is noted, the material having been expelled. Apparently, then, whereas cough may tend to drive a fluid substance such as iodized oil or iodized oil-sputum emulsion deeper into the pulmonary tree it is incapable of similar action on such material as thick tenacious sputum.

#### CLINICAL APPLICATION OF THE OBSERVATIONS

Since it has thus been shown that cough may actually force material similar in consistency to iodized oil deeper into the pulmonary tree, the question logically follows whether or not, in certain surgical procedures cough is not more likely to be a danger than to produce safety. If this were the case, the aim should be to abolish rather than to maintain the cough reflex. This problem arises particularly in thoracoplastic operations for the compression of a tuberculous lung containing cavities. A considerable quantity of fluid pus may suddenly be expressed into the trachea and larger bronchi as a result of operative manipulations and falling in of the chest wall. In patients operated on under local anesthesia as so generally recommended (in order to preserve the cough reflex), or under extremely light general anesthesia cough would be induced immediately. It is likely then, that the patient while getting rid of a part of the pus, might easily force some of it into the alveolar spaces of the healthy lung. Having arrived in the alveoli it may readily remain a sufficient time to cause by contact an acute tuberculosis. On the other hand, this complication might be obviated by the use of general anesthesia and by sufficient morphine both before operation and for at least twenty-four hours thereafter to abolish the cough reflex and the possible effect of gravity can be obviated by operating on the

Macklin<sup>24</sup> has described the elastic membrane and the part that he thinks it plays in the "recoil mechanism" of the bronchial tree. It seems to me that if the nerves to the affected lobe should become involved by pressure or infection, the physiologic movements of the bronchi in that area might be curtailed or abolished, and that a more or less complete relaxation of the bronchial walls would take place, thus changing the bronchi into passive and fixed receptacles for the accumulating purulent material.

CASE 5—A child, aged 12 months, according to the mother, had been in good health until it suddenly became sick with a severe cold three weeks before entering the hospital. The attending physician had made a diagnosis of bronchitis.



Fig 10 (case 5)—Roentgenogram showing collapse of the right lung, particularly the upper lobe, right main bronchus at almost right angle, abscessed nodes (*a, a, a*) in inferior tracheobronchial space.

There had been increasing difficulty in respiration, and inhalations of steam had been used. The mother said that the child had not had fever. There had been a brassy cough. During the third week of sickness, there had been a gradually increasing dysphagia. It had been suspected that there was a foreign body in a bronchus, and the case was referred to me. On the night of admission, the child's temperature was 100 F by rectum, the pulse rate was 110, respiration, 30. Dyspnea was marked, and a steam tent was used. Except for the finding of moist râles over both lungs, the results of the physical examination were negative.

24 Macklin, C. C. A Note on the Elastic Membrane of the Bronchial Tree of Mammals, with an Interpretation of Its Functional Significance, *Anat. Record* 24: 119, 1922.

## SUMMARY AND CONCLUSIONS

- 1 The physiology of the act of coughing is considered
- 2 The experimental results of the action of cough on iodized oil, iodized oil-sputum emulsion and thick, tenacious sputum which had been injected intratracheally into cats, are presented
- 3 It was observed that cough alone increased the rapidity and degree of penetration of iodized oil and iodized oil-sputum emulsion, this was even more marked when tracheal compression was applied thus showing an actual "indriving" action of cough



Fig 11 (cat 13) —Taken after the removal of the tracheotomy tube, cessation of anesthesia and thirty minutes after figure 10. No foreign shadow is shown, the material having been expelled.

- 4 A similar "indriving" action of cough on thick tenacious sputum was not noted
- 5 The relation of cough to certain postoperative pulmonary complications is briefly discussed
- 6 It is concluded that cough may tend to drive fluid substances similar to iodized oil deeper into the pulmonary tree and that it is incapable of like action on a heavier substance, such as thick tenacious sputum
- 7 We wish especially to draw attention to the fact that the usual action of cough is to expel material from the tracheobronchial tree, it may under certain conditions, actually bring about the opposite result that is drive material deeper

measuring 2.5 by 2 cm. The nodes in the inferior tracheobronchial space formed a mass 3.5 by 3 cm, containing from about 3 to 4 cc of pus. The mass was adherent to the esophagus, to the pericardium, to the bifurcation and to both main bronchi, as well as to the adjacent part of the right lung, which showed a limited consolidation in the corresponding area. The mass extended to the spinal column, displacing the esophagus posteriorly and to the left (fig 11). Where the mass was in contact with the pericardium, the esophagus and the bifurcation, the lymph node tissue had ulcerated away, so that the wall of the abscess at these three points was formed by the three structures named, the abscess, therefore, might have ulcerated into any one of the three organs. Results of examination for tubercle bacilli and other micro-organisms in the pus were negative. Injections were made into a guinea-pig, unfortunately, it died in eighteen days. Microscopic sections showed caseous tuberculous lymph nodes. The cultures taken through the bronchoscope showed *Streptococcus viridans* and *Staphylococcus aureus*.

The previous good health of the child, a sickness of only three weeks' duration, with gradually increasing dyspnea and dysphagia, should have made possible a diagnosis of formation of an abscess.

Any major operation in so young a child with pronounced difficulty in breathing would obviously have been out of the question. The only chance for recovery would therefore have been through a spontaneous rupture into the bronchial tree. In the literature there are reports of necropsies on children who died following ulceration of abscessed tuberculous nodes into the bronchi, in these cases, scars were found elsewhere in the bronchial walls, indicating that similar processes had taken place before and had been followed by complete healing. In a recent paper,<sup>2</sup> I reported cases in which large nontuberculous abscesses of the tracheobronchial nodes ulcerated into the bronchi, followed by prompt recovery. The rapidity with which these abscess cavities closed was astonishing. In one of the cases, I observed the opening in the tracheobronchial wall through the bronchoscope on the third day after the discharge of the abscess, and it was remarkably small. As it is impossible to foretell whether an abscess in one of the tracheobronchial spaces will ulcerate into the bronchial tree or into one of the surrounding organs, it occurred to me that "puncture" of the abscess through the tracheobronchial wall would be a logical procedure in cases seen in the advanced stage and in which death was imminent from obstruction to respiration. To this end I have devised an instrument to be operated through the bronchoscope, as shown in figure 12. The bronchoscope devised by me has four channels, namely, one for the light carrier, one for the operating instrument, one for suction and a larger one through which the surgeon can observe the field of operation unhampered by the instruments introduced. The operation should be performed under the guidance of the eye, therefore the shank that carries the knife blade is flexible proximal to the blade, so that the latter can be brought into view by pulling the wire (fig b). The shank runs



0.3 cm in a child 1 year old and from 0.3 to 0.5 cm in adults would probably reach the abscess cavity. The visualization of the topographic anatomy in the area to be punctured is imperative. On the proximal part of the shank is a guard with a set screw and a millimeter scale, so that the surgeon can limit the depth of the puncture by setting the guard. The wall of the abscess may be unevenly thick, and the first puncture may not reach the pus cavity, it therefore may have to be repeated a little distance away. The instrument for "puncturing" is placed in the bronchoscopic channel before the latter is introduced into the trachea, and the operation can be quickly performed, it should be done with the patient in the Trendelenburg position and under local anesthesia in adults and without anesthesia in children.

This method of operating first occurred to me four years ago after bronchoscopic examination in case 4, but I did not have the instrument for "puncturing" made until after the necropsy examination in case 5. In this case, the method described would be the operation of necessity, in cases 1 and 2 in my recent paper,<sup>2</sup> it would be the operation of choice.

#### SUMMARY

The lymphatic system is the drainage apparatus of the lung. Inhaled dusts, after entering the pulmonary lymphatics are carried in the lymph current toward the central depot, i. e., the tracheobronchial nodes, and so are bacteria whether inhaled or blood-borne. On their journey toward the tracheobronchial nodes, bacteria may be intercepted and settle in lymphoid masses or bronchopulmonary nodes.

Much attention has been paid to tuberculous infection of the tracheobronchial nodes, while nontuberculous infections of these nodes have received little notice. Tuberculous as well as nontuberculous infections of the tracheobronchial nodes occurs in both children and adults. The bronchopulmonary nodes have received little attention clinically yet they may be the source of abscesses of the lung. Tuberculous as well as nontuberculous suppuration occur in these nodes. The tracheobronchial and particularly the bronchopulmonary lymph nodes may be potent factors in the causation of bronchiectasis in childhood.

I have not found any clinical reference to the lymphoid masses, but as they, like the lymph nodes, act as filters, bacteria may settle in them, and they may therefore become centers of suppuration.

The healing of inflammatory processes in the lymph nodes is often followed by calcification. Such concretions in the tracheobronchial and the bronchopulmonary nodes not infrequently ulcerate through the bronchial wall and are expelled by mouth. Concretions in the bronchopulmonary nodes may ulcerate into the parenchyma and give rise to abscess of the lung. In roentgenograms of the chest, points of

for cough which is, to be regarded as of advantage to the patient when it leads to the expectoration of abnormal material in the air passages such as foreign bodies, blood and secretion. From one tenth to one third of the inhaled foreign bodies are thus expelled. When there is profuse bleeding into the air passages or flooding with abundant pus from the rupture of abscess or empyema, death from asphyxia is likely unless the fluid can be expelled. If, under such circumstances, the expulsive power of cough is impaired by artificial pneumothorax, or the cough reflex is absent in consequence of unconsciousness from anesthesia or other cause, the danger is much increased.

On the other hand, under certain circumstances cough may be a source of considerable danger. With a weak myocardium, cough caused by an acute respiratory infection or passive congestion may overtax an already burdened heart and become an important contributing cause of cardiac failure. With hemoptysis caused by tuberculosis, cough may dislodge the thrombus in a bleeding vessel and lead to renewed hemorrhage. In the presence of pulmonary tuberculosis, the exertion and heightened air pressure within the thorax caused by cough may activate or keep active the tuberculous process. The expulsion by cough of infected material from one place to another in the bronchial tree may spread infection into previously uninvolved regions.

Considering these good and ill effects, it is no wonder that there is little unanimity of opinion as to the treatment of cough. On the whole, however, cough, in spite of its dangers, is usually to be regarded as of advantage to the patient, and should ordinarily be treated only by those methods which attempt to improve or eliminate the cause. It would certainly seem safer not to attempt to subdue cough and expectoration by drugs when there is such foreign material within the air passages as blood or pus. But when the patient is harassed and fatigued, and his sleep is disturbed by unproductive cough, it may then be desirable to attempt its control by drugs, even though some risk may be taken by so doing. If I understand Dr. Archibald's experiments correctly, there is nothing in his results which indicates that it would be desirable to change this practice, as material of the consistency of tenacious sputum did not appear to be driven further into the lung by cough.

DR J. M. BISAILLON, Portland, Ore. The work which Dr. Larrell did at the University of Oregon in demonstrating sensory nerve filaments in the lung might have an important bearing on this subject, particularly as to the nature of the cough reflexes which are under discussion. The sensory nerve endings were found more in preponderance at the height of the bronchus at the point of division of the bronchi.

DR F. A. C. SCRIMGER, Montreal, Que. One or two points occurred to me in respect to Dr. Graham's reference to the activation of tuberculous infection by use of iodized oil, it is a real danger and I have encountered it several times.

Smaller bronchi are less irritable than larger bronchi. I recall a case in which Dr. Archibald directly opened an abscess cavity in the lung, the walls entirely free from any cough reflex. Smaller bronchi could be touched or probed readily without producing cough while probing of the larger bronchi immediately results in cough.

Regarding postural drainage, I recall a case of chronic pulmonary tuberculosis with cavitation. During the progress of the disease, 10 ounces (0.4 to 0.52 Gm.) of fluid pus ran out of the lung after drainage effort on the part of the patient. The fluid was very thick and sticky, and rested on the floor of the body. After operation there was no further drainage of pus or infection. The degree of fluidity of the pus was such that it could be



One type progresses to straight formation of a mediastinal abscess and is not relieved except by mediastinotomy. The second type breaks into the bronchus and drains in that way. The third type apparently subsides without the formation of an abscess.

Dr Lerche's observations and his instrument for dealing with the type of infection that does not break through the trachea and is difficult of access is exceedingly interesting.

Dr N. W. GREEN, New York. Time does not allow for a long discussion of Dr Lerche's cases. I have done some intratracheal and intra-esophageal work for the past nineteen years, and I have used Dr Lerche's instruments. I have always been impressed with the ingenuity with which they were devised. I think Dr Lerche has courage and skill and vision in his work.

Dr LAARTS GRAHAM, St. Louis. I want to say just a word or two, particularly about the suggestion Dr Lerche makes concerning the relationship of enlarged tracheobronchial glands to the production of bronchiectasis. The work of Mullin of Cleveland has been constructed largely around this idea. I felt that from previous remarks most of the members of the society were not familiar with it. It is interesting work—the work of a rhinologist who has produced enlargement of the tracheobronchial glands experimentally in animals by infection of the nasal sinuses. It closely simulates the work that Dr Crow has already reported, although Dr Mullin did not produce abscesses of the lung, but produced enormous enlargement of the tracheal glands. He has made the interesting suggestion in several of his articles that bronchiectasis in children may be due to the pressure effects of enlarged tracheobronchial glands resulting from infection of the nasal sinuses.

As I said in a previous discussion, I have felt that there is more than a grain of truth in this idea, and it is for that reason that for some years we have been paying almost as much attention to the nasal sinuses in chronic pulmonary suppurations as we have to the lungs. It has been gratifying, even in chronic cases, to see the pulmonary symptoms clear up after proper attention to the nasal sinuses. One sees this sort of thing happen repeatedly. In a child with the history of many years of chronic pulmonary suppuration, even with moderate or advanced bronchiectasis, with extensive suppuration in the nasal sinuses, the suppuration in the nasal sinuses cleared up and the child stopped coughing. He may go along for eight months or a year without any evidence of pulmonary involvement except the coughing up of a little sputum in the morning, but he is practically free from all of his former symptoms. He has an attack of acute coryza, the nasal sinuses are acutely infected again, and he is brought back with all of his former symptoms—cough, sputum and fever. After he has been kept home from school for a couple of weeks, and fairly conservative treatment administered, by means of repeated washing out of the nasal sinuses, the pulmonary symptoms again promptly disappear. Sometimes, if one is persistent and patient enough after two or three cycles of the first event, the child will not have any further attacks of pulmonary suppuration. I am sure, therefore, that there is some connection between enlargement of the tracheobronchial glands and chronicity of pulmonary suppuration. Whether or not it is from pressure, I am not prepared to say.

One other point Dr Lerche brought up is the question of the discharge from the tracheobronchial glands into the trachea of calcified bodies, so-called broncholiths. Broncholiths are not uncommon. In my own experience, I have found them present in 2 per cent of all cases of bronchopulmonary suppuration. One has to be careful in trying to find them because they are small but until all the

bronchi or bronchiole divide (fig 2) In regard to the masses of lymphoid tissue, Miller<sup>4</sup> said

They should be of interest to the pathologist as well as the clinician for these masses frequently serve as centers to which by means of the lymph vessels disease processes may be conveyed The smaller masses of lymphoid tissue may like the lymph nodes, act as filters interpolated in the lymph circulation They also serve as centers to which phagocytes carry their collected material I have followed through serial sections numerous small tubercles situated in the parenchyma of the lung, in every instance I have been able to trace their origin to one of the situations in which I have described lymphoid tissue as being present in normal lung

The lymphatics of the lung are found in the walls of the bronchi along the arteries and veins and in the pleura In the bronchi that

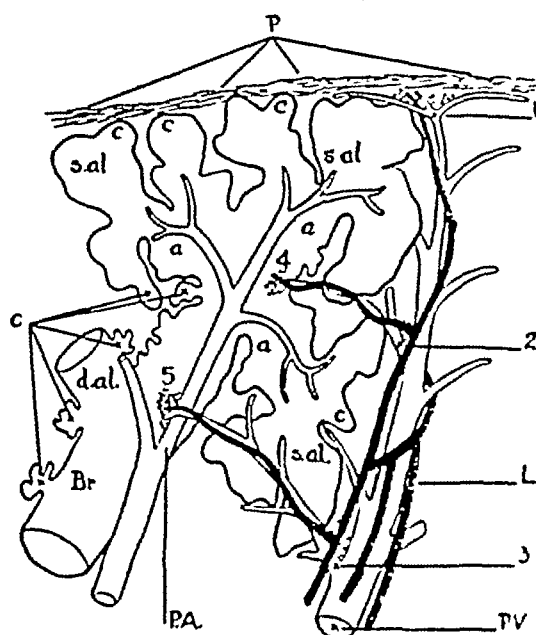


Fig 2—Schematic longitudinal section of a primary lobe of the lung showing the bronchus, pulmonary artery, pulmonary vein, and lymphatic vessels. 1, 2, 3, 4, 5 the five points mentioned in the text. The lymphoid tissue is represented by the stippled area. P, pleura; c, cartilage; a, alveolus pulmonis; Br, bronchus; PA, pulmonary artery; PV, pulmonary vein; L, lymphatic vessels. (Miller)

possess cartilages two sets of lymphatics are arranged to enclose the cartilages and are connected with each other by vessels between the cartilages There is a single plexus of lymphatics in the smaller bronchi Lymphatics do not occur in the alveoli The normal flow of the lymph in the lung is toward the hilum In the part of the pleura is toward the hilum There is a plexus of lymphatics in the pleura these lymphatics are connected with the lymphatics of the lung

<sup>4</sup> Miller, W. S. The Distribution of Lymphatics in the Lung. Anat. Record 5:99, 1911

# THORACIC SURGERY IN AMERICA

A RETROSPECT AND AN OUTLOOK

WILLY MEYER, M.D.

NEW YORK

On looking back over the last thirty years, one sees that it was principally Fell of Buffalo, Matas and Parham of New Orleans, Green and Janeway of New York, Quenu and Tuffier of Paris, and Garré, Kuttner, Friedrich and Sauerbruch of Germany, the latter then assistant at von Meuliez's surgical clinic in Breslau, who in their combined though independent pioneer work laid the foundation for the structure soon to be erected, and gave the principal impetus to the evolution of thoracic surgery in its present modern garb.

True enough, even before that, the chest had frequently been incised with impunity without the help of apparatus designed for the avoidance of the acute pneumothorax. The surgeon had simply taken a chance, because methods for the definite exclusion of such an occurrence, with its possible fatal result, were not known at that time. The opening, with perfect safety and pursuant to a definite plan, of the so-called "virgin" pleural cavity—that is, one without adhesions between the visceral and the costal pleura and without the after effects of a former acute subacute or chronic inflammation—and the method of operating within the thorax with the same safety, equanimity of mind and results as in the abdomen date from the work of the men just mentioned. All of this work was performed in the last years of the nineteenth and in the beginning of the twentieth century. The time from 1898 to 1904, therefore, should be considered as that of the birth of modern thoracic surgery.

At that time only a spark was needed to set aflame this material gathered from the various countries in order to illuminate the whole civilized world. This spark was supplied when the American Medical Association, through its Section on Surgery and Anatomy, placed on the program of the annual meeting to be held in Chicago in 1908 an international symposium on "Intrathoracic Surgery." Professor Schaefer of London and Dr. Sauerbruch, then professor extraordinary of the University of Marburg, were the invited guests, together with representatives of the American medical profession, foremost among whom were Samuel Robinson, Nathan W. Green, H. H. Janeway, George E. Fell and John B. Murphy, men particularly interested in this chapter of surgery. The year 1908 might therefore be considered the beginning of modern thoracic surgery on a larger scale in America.



in Washington, in 1922, that, for the sake of safety, apparatus for the use of differential pressure should always be on hand when the thorax was to be entered. In other words, the surgeon who incises the chest without such preparation takes unjustifiable chances in handling the patient, whose life it is his duty to protect with all available means.

Meanwhile Gwathmey, following Tiegel's principles, adapted his well known anesthesia apparatus to the needs of thoracic surgery by fastening the rebreathing bag, which had already been in use for many years, tightly on the face of the patient. The application of the usual mixtures of various anesthetic gases plus oxygen under pressure, wherever employed with the help of this apparatus, was found to be sufficient, simple and safe. Some surgeons still made use of pharyngeal anesthesia by blowing the gas under pressure directly into the pharynx through tubes placed in the nostrils. The negative chamber, positive pressure cabinets and intratracheal insufflation had become obsolete.

At the Lenox Hill Hospital in New York, the space occupied by the thoracic pavilion was given to the roentgen-ray department, which could not find any other quarters and which needed to expand. This necessitated the dismantling of the negative chamber in 1923, of course, all parts were saved and stored. But will the chamber ever be reconstructed? Most likely not. From a purely scientific standpoint, the dismantling of this negative chamber must be considered a loss, for it was the most complete physical apparatus of its kind in the world. It might have been useful in the future in emergencies, e. g., in acute emphysema of the mediastinum and the extrathoracic soft tissues and also in complicated postoperative conditions. In such instances it might save life when all the usual hypodermic, intravenous and chemotherapeutic attempts, including blood transfusion, have failed and only such physical means, the breathing of oxygenated air under pressure *for a number of hours*, can restore proper heart action. Patients not completely enervated may perhaps stand the rubber rebreathing bag over the face for hours without being anesthetized, but I am sure that the majority will be too feeble and will eventually die. I believe that a cabinet of some kind is required in such cases, so that the patient will be in an almost sitting posture, with the apparatus covering the head—somewhat on the lines of the old Brauer apparatus. In such a cabinet the patient will be able to breathe air and oxygen under pressure with comfort for as many hours as may be found necessary to overcome the great danger of a failing and otherwise intractable heart muscle.

I shall never forget an experience I had in 1910. After a bilateral vagolysis for a sacculated esophagus consecutive to cardiospasm of long standing performed on a depleted woman, aged 46, the heart failed to respond to the usual means of stimulation. The placing of her head for nine hours in our plus-pressure cabinet, the only one available at that



hospitals, they will find up-to-date help, and the lives of many will be saved by careful, trained observation and by timely intervention. But what facilities do they find in smaller communities with the less elaborate, but always well equipped, hospital? In many places such patients are often left to die after a diagnosis of severe "internal injury," because the teachings of present day thoracic surgery have not yet reached the medical profession at large. Those who are now called on to minister to this class of patients with severe internal injury of the chest have not received the training in this branch of medicine at the medical colleges that they have received in performing operations on all other parts of the body.

The teaching of thoracic surgery, at least of its principles, is therefore a much needed addition to the medical curriculum. Probably some have already introduced it, or are about to do so, but as far as I know, this has not been done in medical colleges at large, and yet this training is an absolute necessity. It will, of course, burden still more the already overcrowded curriculum of the medical students, but wise adjustment by the proper committees will overcome this difficulty. Less important subjects may be left out and thoracic surgery added. At present, the student is required to know the anatomy and physiology, perhaps also in some colleges the surgical pathology, of the chest and the organs it contains. Operative surgery of the chest, radical and conservative, and after-treatment should be added. It is so fascinating that, once begun, the majority of students will be enthusiastic over it, and the young surgeons I feel confident, will never give it up, they will be glad to add it to their daily routine. They will quickly realize the necessity of being prepared to meet the possible dangers of acute pneumothorax, and that the technique of operations within the chest is not different from that of operations on the abdomen, they will also see that it is not proper for the well trained surgeon to draw the dividing line of his work at the diaphragm, thus being obliged to leave surgical conditions above this muscle to someone specially trained.

While it is proper for large institutions with many hundreds of beds and with a vast amount of material to have specialists for every branch of surgery, scientific and operative, this cannot be done in small towns. If not all, at least the majority, of the members of the attending staff of smaller hospitals will soon have to take active interest in the cure and alleviation of patients with thoracic diseases. From the attending physician down to the adjunct, they will have to meet on common ground, they will have to cooperate and establish the borderline in sub-acute and chronic cases when the patient's treatment must pass from the internist or specialist to the surgeon. And what a benefit this will mean for the further rapid, more detailed evolution of this branch of surgery. Many minds working in the same direction usually obtain better, quicker and more important results than does one man working alone.



Fig 5 (case 2) —Roentgenogram showing bronchiectasis of the right middle and the lower lobes, after injection with iodized oil 40 per cent The arrow points to the stricture caused by the cufflink

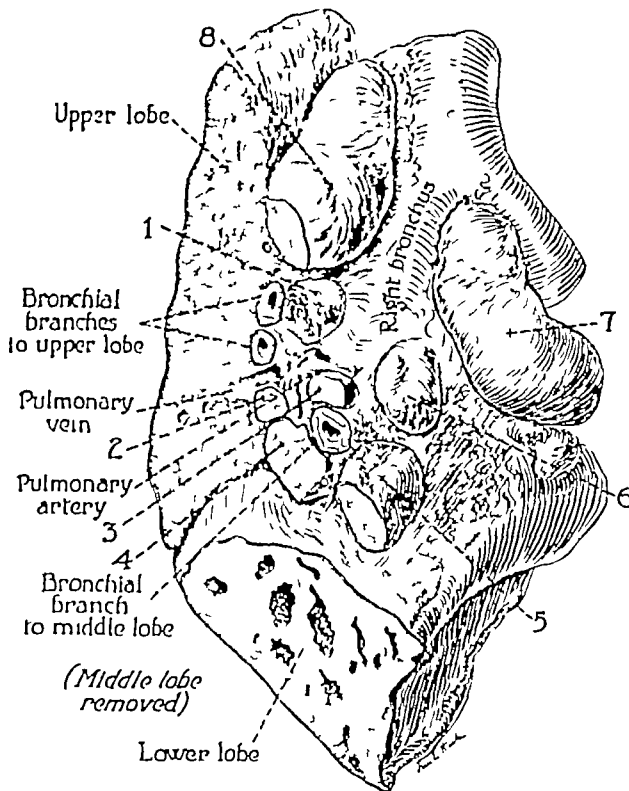


Fig 6 (case 2) —Drawing showing hardened specimen of the lung 1 to 6 indicates bronchopulmonary nodes, 7, inferior tracheobronchial nodes, 8, right tracheobronchial nodes, 2, 3 and 4 are encroaching on the vessels, 4 is encroaching on the middle lobe bronchus



# SUPPURATIVE PERICARDITIS

REPORT OF THREE CASES \*

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Suppurative pericarditis is a disease not often recognized during life, which accounts for the relative rarity of the performance of pericardiotomy. Only slightly over 100 operations for the relief of this disease are recorded in the surgical literature. I have added the reports of three cases.

## CASE REPORTS

*CASE 1—History*—Joseph Giordano, aged 1 year, of Italian parentage, was admitted to the babies' ward of the New York Post-Graduate Hospital on Nov. 14, 1916. He was breast fed and previous to the present illness had been healthy. For four weeks before admission to the hospital, he had been ill with fever, rapid breathing, cough and an expiratory grunt. After two weeks there was improvement for a few days, followed by a recurrence of the symptoms. The appetite was fair; the infant did not vomit and slept poorly. On admission, he weighed  $21\frac{1}{4}$  pounds (9.6 Kg.), the temperature was 99.2 F., pulse rate, 140, respiration, 52. The infant was fairly well nourished and developed. He appeared acutely ill and was dyspneic.

*Physical Examination*—The head and the neck presented nothing abnormal. The lips were dry and scabby, the tongue was coated and the buccal mucosa was clean. The child had four upper and two lower teeth. The pharynx and heart were normal. Many mucous râles were heard over both lungs, there was dulness over the left lower lobe, posteriorly. Bronchial breathing was not heard. The abdomen was moderately distended and tympanitic. No masses were palpable, and there was no point of tenderness. The liver was palpable 2 cm. below the costal arch. The spleen was not felt. The extremities were normal except for some swelling of the dorsa of the feet.

A provisional diagnosis of resolving pneumonia was made.

*November 16* A roentgenogram of the chest showed consolidation of the lower lobe of the left lung.

*November 18* Scattered subcrepitant rales were heard throughout both lungs, posteriorly. Over an area of the chest, anteriorly, from 2 cm. to the right of the sternum to the left midaxillary line, respiratory murmur and cardiac sounds were distant. Bronchial breathing was heard at the apex of the left lung.

*November 20* A roentgenographic examination showed a fairly extensive pericardial effusion. Pleural effusion was not present.

*November 23* Dr. Roger Dennett aspirated about 25 cc. of thick greenish-yellow pus from the pericardium. A culture showed *Bacillus influenzae*.

*Operation*—On November 25, with the infant in a semisitting posture, a local anesthesia (0.5 per cent procaine hydrochloride solution) was given and a curved incision made along the left margin of the sternum and out over the fifth costal cartilage. The cartilage was resected, the internal mammary artery

of the lung. Miller<sup>2</sup> stated that the quantity of lymphoid tissue in the lung increases from childhood to old age owing to irritation from the continuous deposits of dusts. In case 2 the patient had just had whooping cough which is always accompanied by some bronchial infection and probably also infection of the bronchopulmonary nodes when he aspirated the cuff link. Fresh infection was thereby superimposed, and the already infected nodes became blocked with infective material, which extending from the lymphatics into the surrounding tissues gave rise to inflammation and destruction of the lymphatics. Hence dust was



FIG. 8 (case 3).—Roentgenogram showing marked fibrosis and calcined nodes at the division of stem bronchi on both sides especially in the right lung at *a* and *b*; abscess at *c*; bilateral bronchiectasis and abscess. The left side was injected with iodine oil 40 per cent.

not carried to the middle and lower lobes. Coffin<sup>18</sup> found that lymphatics will grow into granulation tissue but where there is a chronic inflammatory process with new infection constantly added the lymphatics are destroyed as shown by Koester<sup>19</sup>.

18 Coffin T. H. On the Growth of Lymphatics in Granulation Tissue. Bull. Johns Hopkins Hosp. 17:277, 1906.

19 Koester. Die Bedeutung der Lymphgefäße bei der chronisch-granulierenden Entzündung. Berl. klin. Wchnschr. 20:748, 1883.

The heart beat was rapid but regular. Murmurs, enlargement or displacement were not noted. The abdomen was flat and tender, masses, rigidity or hernia were not present. The liver and spleen were not palpated. The extremities were normal. The knee jerks were equal but sluggish, otherwise the reflexes were normal.

The temperature was 101 F, respirations, 36, pulse rate, 132.

The following morning, on examination of the chest, a few small, crackling râles were heard just outside and below the left nipple. Bronchial breathing was heard over the same area. Dulness was not noted on percussion over this area. Urinalyses were negative. The diagnosis of bronchopneumonia was made.

A complete blood count revealed hemoglobin, 70 per cent, red blood cells, 4,600,000, white blood cells, 13,200, differential count polymorphonuclears, 68 per cent, lymphocytes, 31 per cent, eosinophils, 1 per cent.

*Course of Illness and Operation*—The child apparently improved rapidly after admission, and on the third day of her stay in the hospital the temperature became normal, respirations were about 28 and her pulse rate, 120. On the fifth day, after her temperature had been normal for two days, she had a sudden rise in temperature to 104 F, the pulse rate became more rapid (144) and respirations rose to 60. Examination of the chest at that time apparently did not show any abnormality of the lungs. Examination of the heart showed a slight enlargement of the cardiac area to the left, but none to the right of the sternum. No friction rub or murmurs were heard. The heart sounds were somewhat distant and weak. The roentgen-ray examination revealed the total area of the heart markedly increased and the borders of the heart straightened with a broadening in the region of the superior vessels suggesting the likelihood of pericardial exudate. Another roentgen-ray examination was made the following day and the foregoing symptoms were confirmed.

The symptoms remained about the same, and on June 23, eight days after admission to the hospital, the pericardium was aspirated and a small amount of thick yellow pus was obtained. The needle was inserted in the fifth intercostal space about 0.5 cm to the left of the sternum and was pointed upward and toward the right side.

There is much discussion as to the best site for a pericardiocentesis. Osler says that the fourth or fifth intercostal spaces near the sternum are the sites most often selected. Hibblom advises the fifth interspace just inside the left border of dulness. Kocker recommends the fourth or fifth interspace to the right of the sternum, if there is considerable dulness to the right. If the diaphragm is depressed, Osler says that the best point is high in the angle between xiphoid cartilage and the left costal margin, the needle being directed backward and upward. There is probably less danger of going through the pleura at this point. A small aspirating needle about 2 inches (5 cm) long should be used, the greatest care being taken to insure an aseptic operation.

After the diagnosis of purulent pericarditis was confirmed, the patient was transferred to the surgical service. Examination of the chest at that time showed more marked signs of a pericardial effusion. The heart sounds were distant, the pulse fairly strong and the heart rate, about 140 and regular. The area of cardiac dulness at that time extended on the left side to the anterior axillary line, in the third, fourth and fifth interspaces, there was some enlargement to the right of the sternum. No murmurs or friction rub were heard. Thick mucous râles were heard over both lungs anteriorly and posteriorly. No areas of bronchial breathing were heard.

In the etiology of bronchiectasis, the following factors are commonly considered aspirated foreign bodies, kinks of the bronchi, pressure by aneurysm or tumor from without, growth in the bronchus, tuberculous or syphilitic stricture, webs, bronchitis, peribronchitis, bronchopneumonia and pleuritic infection, influenza and tuberculosis, occasionally pressure from enlarged lymph nodes is mentioned

In the young, the lymphatic system of the lung is "open," and the lymph nodes of the bronchial tree are probably affected in every case of infection of the lower respiratory tract, but in whooping cough, measles,



Fig 9 (case 4) —Roentgenogram showing the heaviest markings in the upper lobes and at the division to upper lobe bronchi on both sides. Arrow *a* indicates enlarged nodes in the left tracheobronchial space, arrow *b* points to abscessed nodes in inferior tracheobronchial space

influenza and tuberculosis the nodes seem particularly prone to become involved. Forgeron<sup>21</sup> reported twenty necropsies in children between the ages of 3 months and 5 years in which death was due to whooping cough in ten cases, to influenza in two, to diphtheria in one, bronchopneumonia in one, edema of the lungs in one, mixed infection with tuberculosis

<sup>21</sup> Forgeron, H. *l'Adenopathie tracheobronchique simple chez l'enfant*, These de Paris, 1922, p 191

*March 18* An acute suppurative otitis media developed in the left ear

*March 21* Thoracotomy was performed under local anesthesia, with removal of 3 inches (7.6 cm) of the eighth rib, posterior axillary line. A large amount of pus was evacuated.

*March 23* The pericardium was aspirated and 1,600 cc of thick greenish pus withdrawn. Culture of this pus showed pneumococcus, type II.

*March 25* The sixth and seventh left costal cartilages were removed under local anesthesia, the internal mammary artery was ligated, and the pericardium was exposed by blunt dissection. The heart was adherent to the anterior pericardial wall. An incision was made in the pericardium to the left of the adherent heart, and about 1,500 cc of pus was removed with a suction apparatus. As in case 2, irrigation was not carried out, and drainage material was not placed in the pericardium. The pericardium was sutured to the intercostal fasci and muscles. The wounds were dressed daily for five weeks, when both the empyema and the pericardial wounds were practically healed. About this time, swelling of the feet and legs developed and myocardial insufficiency was feared. The patient was returned to the medical service of Dr Shattuck who made the following notes:

*May 1* "Lungs—right posteriorly—from angle of scapula to base, dullness diminished; voice and breath sounds and bronchial breathing with occasional fine moist râles. Left, posteriorly—dullness and diminished breath sounds at extreme base.

Heart. Sounds are good, not rapid, regular.

Signs in chest show that there is still a considerable pathologic process, either unresolved consolidation, encapsulated or free exudate. Roentgenography or exploratory puncture of right side, particularly, needed to clear up the picture."

*May 3* The patient left the hospital against the wishes of the attending physicians.

*June 18* After the patient went home, the empyema wound opened, and considerable pus escaped. Drainage continued for about two weeks. Improvement was rapid and progressive from this time. There was considerable gain in weight and increase in stature, and satisfactory general development. When last seen and heard from, the boy appeared to be in perfect health.

*Summary*—1 In this case the suppurative pericarditis was secondary to a severe attack of double pneumonia, and complicated by a left-sided empyema. The infecting organism in the pericardial exudate was the pneumococcus, type II.

2 The pericardial effusion was discovered on the twelfth day, aspiration of 1,600 cc of pus was carried out on the twenty-fifth day, and pericardiotomy was performed on the twenty-seventh day of illness. The sixth and seventh left costal cartilages were resected in exposing the pericardium. The cavity was not irrigated, and drainage material was not placed in the pericardium.

3 Convalescence was protracted and stormy, but the patient eventually recovered.

#### COMMENT

Suppurative pericarditis, in my opinion, is never a primary disease. It is always a secondary or complicating infection of some lesion or lesions. It is usually due to direct extension of infection from the lung or from the lung and the pleura. It may follow wounds in the chest,

case 3, there were calcified nodes and pronounced fibrosis at the angle of division of the bronchi to the various lobes, and the enlarged (tuberculous) inferior tracheobronchial nodes in case 5 caused death by compressing the bifurcation and bronchi. The cases just mentioned indicate that, particularly in childhood, swollen lymph nodes, tuberculous or nontuberculous, may compress the bronchi as well as the vessels, the effect of such compression in the presence of infection may lead to bronchiectasis.

I wish to call particular attention to the bronchopulmonary nodes as potent factors in the causation of bronchiectasis in children. The lymphoid masses probably act in a similar way at the divisions of the smaller bronchi. When these nodes and masses are enlarged, inflamed and associated with periadenitis and edema, their position at the angles of division of the bronchi and bronchioli renders them peculiarly apt to interfere with the function of important structures. The nodes may compress the bronchi directly, or the fibrous tissue following the acute periadenitis may constrict the necks of the affected bronchi and prevent proper ventilation and drainage, the nodes may exert pressure on the vessels and give rise to congestion and edema, or the nerves may become affected by pressure or inflammation. It has been observed that periadenitis with edema surrounding the recurrent laryngeal nerves in the mediastinum has caused loss of function in the corresponding vocal cord, and that a similar cause in the case of the phrenic nerve resulted in insufficiency of the diaphragm. Therefore, it seems logical that a similar cause may have the same effect on the nerves of the lung. The nerve supply of the lung, according to Miller,<sup>22</sup> comes from the pneumogastric reinforced by branches from the second, third and sometimes the fourth thoracic ganglia of the sympathetic nerve, the nerves follow the bronchi throughout their course and are usually found associated with a branch of the bronchial artery in the layer of connective tissue which surrounds the bronchi. The bronchial musculature, as described by Miller,<sup>23</sup> provides for the elongation of the bronchi and bronchioli during inspiration and the shortening during expiration.

In extreme expiration the dorsal and lateral branches form an acute angle with the main stem bronchus, while in inspiration they open out, the angle becomes wider and at the same time they elongate. This change is necessary in order that provision may be made for the adequate expansion of the air spaces.

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22 Miller, W. S. A Study of the Nerves and Ganglia of the Lung in a Case of Pulmonary Tuberculosis, *Am Rev Tuberc* 2 123, 1918.

23 Miller, W. S. The Musculature of the Finer Divisions of the Bronchial Tree and Its Relation to Certain Pathological Conditions, *Am Rev Tuberc* 5 689, 1921.

drained. The next two patients had streptococcic septicemia, and both died. In the fourth case the bacteriology was never clear. So far as the pericarditis was concerned, a smear was made from the fluid aspirated from the pericardium and many different kinds of organisms were found. I looked up the case recently, but I could not find a definite report on any culture. The patient died of septicemia. I do not believe that if a patient has a general septicemia and pericarditis, drainage of the pericardium will cure him. We all try this procedure, but it is hopeless.

I have always been interested in closed suction technic in certain cases of empyema, and I do not see any reason why it cannot be applied to pericarditis. In fact, I have used it. The case in which my patient recovered was presented at the Boston meeting of the Society in 1920. The patient was operated on by a closed suction method, a small catheter being placed in the pericardium cavity. This technic is based on the idea that it is the least severe operation one can perform. It does not allow air to enter the pericardium, which, I think, is probably a good thing. The catheter can be placed around the heart and into the posterior part of the pericardium, which is the point to drain.

Suction was the only postoperative procedure used in the case in which this technic was employed and in which the patient recovered. The catheter was shut off except when suction was being made. Irrigations were not used. Eventually, after four weeks, when practically no pus was discharged, and when this pus contained one organism to five or six fields, the catheter was removed. The patient recovered, he is well now after seven years.

Two other patients were operated on by this method. Both had streptococcic septicemia, and both died, which did not surprise me.

In the fourth patient, a costal cartilage was removed. It seemed to me that he had a small pocket of pus outside the pericardium and a large amount of pus in the pericardium. One or possibly two small rubber tubes were used for drainage. Irrigation with salt solution was instituted in this case and in one of the other cases in which the closed suction method was used. I could not see that the irrigation had any effect. I think that Dr. Pool's case, in which a surgical solution of chlorinated soda (Dakin solution) was used for irrigation, was striking. I do not see any reason why the solution should not be used.

DR. CARL A. HEDBLOM, Chicago. The chief reason, in my opinion, for the frequent failure of physicians to diagnose pericarditis with effusion, at least in cases in which the condition is suspected, is the fear of an exploratory pericardiocentesis. If a large needle or a trocar is used, as detailed in many case reports, there is, I believe, some danger of injuring the heart or of producing hemorrhage, but a large needle is not necessary, and a trocar should never be used. In my experience, an ordinary medium-sized hypodermic needle, no. B-D, about 3 cm. long, is large enough, and, in my opinion, it does not involve any more risk than an ordinary exploratory aspiration of the pleural cavity. I have aspirated several hundred cubic centimeters of effusion at one sitting through such a needle.

An early positive aspiration will establish the differential diagnosis and will determine early treatment.

One of the possible sources of error is to assume that there is no pericardial effusion from one dry tap. The usual point for inserting the needle, as Dr. Peterson says, is at the left of the sternal margin. It has been shown, however, by Williamson and others, that the heart may be pushed forward

Röntgenograms showed that the right lung contained less air than the left, particularly the upper lobe, and the left upper lobe was more cloudy than the lower lobe (fig 10). Enlarged bronchopulmonary nodes were seen, some were calcified. The mediastinal shadow was broader than normal in the upper right part. The right main bronchus seemed to be at almost right angles with the trachea. There was a large triangular shadow below the bifurcation and the main bronchus; no foreign body was seen. Bronchoscopic examination revealed some edema of the epiglottis. The lower wall of the right main bronchus and the corresponding part of the bifurcation appeared as if pushed upward, causing



Fig 11 (case 5)—Roentgenogram of necropsy specimen. Abscess cavity is indicated by *a*, displaced esophagus injected with barium mixture by *b*, trachea by *c*, and right bronchus by *d*.

considerable narrowing of the lumen of the right bronchus. The mucosa was red and edematous. A foreign body was not seen. Culture was taken from the bifurcation through the bronchoscope. The diagnosis was infection and enlargement of the lymph nodes in the inferior tracheobronchial space compressing the right main bronchus and the bifurcation. The child died two days later.

Necropsy revealed an enlarged thymus gland to which several enlarged lymph nodes adhered. There were some enlarged preaortic nodes, and the eparterial group was considerably enlarged. The nodes of the left tracheobronchial group were small and soft, while the right group formed a firm, somewhat flat mass,



amount of old blood coagula were removed by irrigation, prolonged drainage followed. The patient recovered and his wound healed, when I saw him he was in good condition.

One physician does not usually see a large number of these cases, yet they are frequently found. My personal opinion accords with that of Dr Hedblom, *i. e.*, that aspiration should be performed when there is an enlarged shadow of the heart much oftener than is done in the medical ward. Why not also plunge the aseptic needle into the pericardium as we know every physician does with reference to the pleural cavity? If he does not want to do it himself, let him call a surgeon. Certainly many patients with acute infectious diseases could improve considerably if simple aspiration were performed repeatedly, if necessary.

Regarding surgical treatment, personally, I can never forget what I might call the thrill I had at our Boston meeting when Dr Whittemore told us of the case in which he saved a boy, aged 12, who had influenza with complicated *pericarditis*. I have always believed in the correctness of closed drainage after intrathoracic operations. That was the guiding thought several years ago at the Lenox Hill hospital, when Dr Pickhardt and myself and members of the staff, discussed the best treatment for *empyema* according to the experience gained from air-tight drainage after thoracic operations. We came to the conclusion that it would be best not to plunge in the trocar as we had done a number of times according to the old Bulau method of the last century, which had shown brilliant results at times, but that we should do the work under the guidance of our eyes. We selected the following method. Under local anesthesia, we resect as long a piece of the rib as one can, then make as long an incision as possible in the posterior fold of the periosteum of the rib, and the appearance within is noted. Then, under the guidance of the fingers, and through a stab wound, the drainage tube is placed farther down, or 2 inches (25 or 5 cm.) from the diaphragmatic surface. This done, we close the entire chest wound in layers, making it air tight. We have had splendid results with this procedure. Dr Pickhardt told us at the Chicago meeting of this Society of his series of patients who had been treated and cured according to this so-called "physiologic drainage *empyema*." In the course of years, we have repeated this operation, and recently I was particularly interested in a brilliant textbook on children's diseases by Frazier of Edinburgh in which he published about seventy cases in which this kind of physiologic drainage was used with most satisfactory results.

I believe that many patients on whom thoracic operation is performed recover more easily, as they sometimes do in the hands of experienced men, if in the majority of cases the simple air-tight drainage would be added for forty-eight hours.

With this and with Dr Whittemore's brilliant personal experience in mind, I firmly believe that the closed method of pericardial effusion will probably prove to be the best. I believe this still more firmly since I had the opportunity of observing two acute cases that occurred in the hospital while I was still in active service. One patient was operated on by Dr Pickhardt and one by myself. We used open drainage method, both patients died. I decided that if I should ever have a case again that required this kind of operation, I would not use the open method of after treatment, particularly in adults. I think there is a difference between the treatment required for adults and children. I would use the method of open incision close to the sternum as possible and thoroughly remove the coagulated material in the pericardium, I would then know that after suction the sac was as clean as was possible. I

smoothly in the knife-carrying tube, and this tube fits snugly in its channel in the bronchoscope. The proximal end of the shank to which the handle is attached is flexible, so that it can be worked out of the way. The depth of the puncture must be considered beforehand, as it

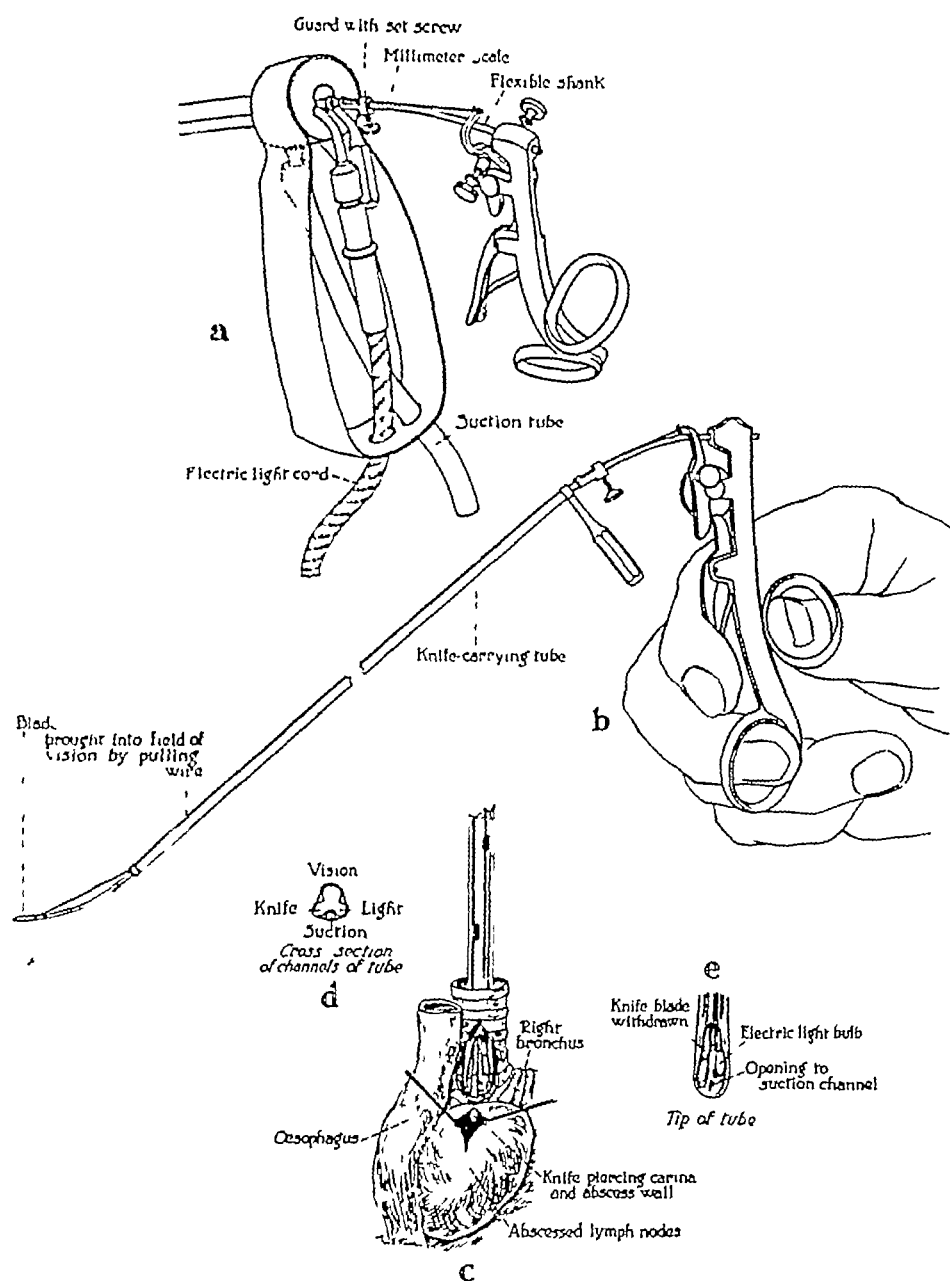


Fig 12 (case 5)—Bronchoscope used by the author and instrument for “puncturing” abscess of the tracheobronchial lymph nodes

will depend on the thickness of the bronchial wall and on the anatomic relations in the area to be punctured. The thickness of the tracheal wall when the patient is from 1 to 2 years of age is 0.17 cm, when he is from 15 to 16 years, it is 0.22 cm, therefore a puncture from 0.2 to

Two transfusions were given according to the Lindemann method, and the patient finally recovered. It is possible that the transfusions did not do any good, but I think it should be borne in mind that transfusion is a notable aid toward recovery from *Streptococcus hemolyticus* infection of the blood.

DR HOWARD LILIENTHAL, New York. I have had experience with four patients—two recovered and two died. One of the patients who died, a little child with empyema and septic pericarditis was operated on, the other patient had actino mycosis with secondary infection of the pericardium caused by unskilful puncturing with the needle. The pericardium was entered, and this produced pericarditis. The patient died of the disease, whether of pericarditis alone or not, I cannot say.

The problem of closed suction is a totally different one in pericarditis from suction in drainage of the pleura. Closed suction in the pleura is intended to produce a rather prompt dilatation of the lung, bringing it to the surface and obliterating the pleural sac. There it is justifiable. I cannot see the advantage of it in the pericardium, but I can see many disadvantages. If one should wish to perform lavage, it is extremely dangerous to irrigate through closed suction. Patients have died as a result of this. In a case of Dr Herman Roth, the patient collapsed and almost died before Roth found out what the trouble was and pulled the tube out, the patient revived. His fingers had relaxed, his pupils had dilated, his heart had stopped and breathing had ceased but returned with removal of the tube.

The problem is a totally different one from that of empyema. In fact, in the older operations for pericarditis, some of which were successful, the pericardium was deliberately held open. I have always sutured the pericardium to the skin or to the superficial tissues to maintain potency. An advantage of this is that one can reach in with a probe or soft rubber catheter and get to the posterior sac of the pericardium, making sure that it is empty. The pericardium acts exactly as the rest of the chest so far as respiration is concerned. With a respiratory effort like cough, the walls of the pericardial sac as well as the pleural walls, are forced together, and there is extrusion of fluid with suction on in aspiration.

It has been suggested that diagnostic aspiration may safely be made from behind, and it has been performed in one or two instances. I wish to warn against this. There is too much danger of infecting the mediastinum with pus from an infected pericardium to make it worth while except in a case of hydropericardium in which aspiration is performed for relief, in that case it is easy enough to get at it from in front.

I strongly disapprove of the closed suction methods in pericarditis, even though we have heard a report by Dr Whittemore of his successful case. I should like to hear the results of a series of these successful cases before I should care to change my mind.

DR ROBERT T MILLER, JR, Baltimore. I have had two cases of this kind. The only reason for speaking about them is that they seem to be unusual. The first occurred a little over eighteen years ago. The child had suppurative pericarditis complicating scarlet fever. Resection of the fourth and fifth left cartilages was performed. When the wound was dressed the pericardium was irrigated until the returning fluid became clear, following which a rubber protective tissue drain was inserted into the pericardial sac. The child died in spite of all efforts, his death was apparently the result of loss of blood from the wound—a loss of blood which in a way suggested hemophilia. He did not bleed in large amounts, but there was a continual loss of blood which

calcification are often seen peripherally in the lung, beyond the area of the lymph nodes, and these points of calcification may be the results of healed inflammatory processes in the lymphoid masses

I wish to make a plea for the use of the terms "tracheobronchial" nodes and "bronchopulmonary" nodes, instead of hilum nodes, bronchial nodes at the root of the lungs and other terms

#### ABSTRACT OF DISCUSSION

DR ALLEN WHIPPLE, New York I have always followed Dr Lerche's studies of the arrangement of the lymphatic system in the mediastinum with great interest I am pleased to see that he is still pursuing the subject and has brought out the effects of enlargement of the bronchial nodes, particularly in children, on the development of bronchiectasis It seems to me that is a logical sequence of events as he outlined it

Dr Lerche has emphasized especially the role of pulmonary infection in its relation to the involvement of the tracheobronchial and bronchopulmonary nodes That is of special interest to the thoracic surgeon On the other hand, I think there is a phase of it that is just as interesting, and from the standpoint of the general surgeon is even more important, i e, the involvement of the mediastinum following abdominal infections

I wish to stress that feature of it particularly and will take a short time to discuss it

In the last three or four years, I have seen four cases that impressed me particularly as cases of infection of the mediastinal lymph node following abdominal lesions A man came to me with the history of severe cholangitis He recovered from it, when suddenly his temperature rose and he became prostrated He was sent to me with a diagnosis of cholangitis without jaundice, however In going over the records concerning the man's physical examination, I was much impressed by an area of dullness situated to the right side of the sternum, with signs posteriorly as well During the examination, he suddenly began to cough and coughed up foul pus He was taken immediately to the fluoroscopy room and a collection of fluid was clearly outlined to the right of the sternum, in the mediastinum, causing a definite blocking of the postpericardial shadow There was a fluid level, and it seemed to be a case of mediastinal abscess breaking through into the bronchus Bronchoscopy was not performed, but the patient continued to cough up pus, in a few days, he was much better, and he recovered from that attack During his convalescence, he went to California, and on his way back through the Panama Canal, he had a recurrence of bile duct infection He arrived in New York with severe cholangitis An operation was performed, although at the time the man showed a continuance of the shadow to the right of the sternum He died from severe postoperative pneumonia I think that the infection had passed through the diaphragm into the mediastinal lymph nodes and had resulted in an abscess which broke through the bronchus, and that there was a continuing line of infection between these two structures

Another case was one of streptococcus infection Beginning as peritonitis, a double empyema, a left subphrenic abscess followed At the time I was taking care of the boy, the same shadow developed to the right of the sternum The infection did not break through the bronchus and the boy recovered

The other two cases are similar, and I will not take the time to describe them, but I want to stress this There are three kinds of mediastinal infection

Dr Ellsworth Eliot There have been about five cases of suppurative pericarditis within the past few years but the patients were adults It would almost seem that children are the ones who have a fair chance of recovery and that the mortality rate of adults is much higher In diagnosis, I think it is of interest to note the unaccountably rapid pulse rate that occurs with pericarditis in marked contrast to the temperature A much more delicate test is possible with the aid of a blood pressure machine By this method, one may listen around the upper limits of the systolic pressure and may note when the first sounds come through on expiration The number of millimeters of mercury registered by the blood pressure machine at the time when the sounds first come through on expiration should be noted The same notation should be made at the time when the sounds are heard equally well on inspiration and expiration The difference in millimeters of mercury between these two registered pressures may be greatly increased over the slight difference that may normally occur If that range is a high one, it is a clear-cut indication of the paradoxical quality, and has been present in all the cases that I have seen In one case it was interesting to note a complete disappearance of a marked paradoxical pulse on aspiration

The aspiration externally appeals to me, as Dr Hedblom remarked, internal to the outer margin of the dullness and external to the apex All of the patients on whom it was necessary for me to operate died They were all adults The last case was caused by type III pneumococcus A wide open type of operation was performed similar to the one recommended by Dr Pool The patient lived for three weeks after a wide open exposure As the operation was performed under a local anesthetic, it was possible to push the pleura back and make a wide opening in the pericardium and stitch it to the skin When a clamp was placed on the pericardium at its junction with the diaphragm, the patient complained of pain in the left shoulder That was in the region of the fifth and sixth rib, as Dr Lord brought out A surgical solution of chlorinated soda (Dakin solution) was used in this case part of the time It was possible to pass a catheter to behind the heart and to introduce a finger between the heart and diaphragm and toward the apex with little, if any, effect on the patient Suction drainage was also used part of the time The patient had extensive lesions elsewhere She had an enormous abscess of the thigh and infection of the knee joint caused by type III pneumococcus At the autopsy, adhesions were found, but there was no accumulation of pus in the pericardial sac, and the pleural cavity was clear

Two or three other cases that we have had have led us to consider the possibility of drainage by the posterior route in pericarditis, particularly if the pericarditis is associated with left empyema We have been looking for a case in which the left side of the chest is involved with an empyema so that the approach to the pericardium can readily be made through the pleura I saw one case without empyema with Dr Whipple, which I think he has reported He made a posterior incision of considerable extent, near the diaphragm, avoiding the phrenic nerve The pericardial drainage in this case appeared to be satisfactory, though the man died after living several weeks

It is striking to see how close the pericardium is to the wall of the left side of the chest when distended with fluid I have had occasion to see that at autopsy, and to see how close to the wall the pericardial sac actually is in the region of the seventh and sixth spaces It seems as though one has to travel a short distance in making a posterior lateral incision in order to enter the pericardium at the site that would seem to be the most favorable

broncholiths are removed, the patient is likely to continue to have the symptoms of chronic pulmonary suppuration, when the last broncholith has been removed, the patient will usually recover. One patient has expectorated as many as 126 broncholiths over a period of six months. Some of these are exceedingly small. I have a feeling that as Lerche expressed it, the origin of many is in the tracheobronchial glands. The patient is not likely to get well until all of the broncholiths are discharged.

DR L. T. LEWAND, New York. I should like to emphasize one point that Dr Lerche brought out, that is, that following infectious diseases of childhood bronchiectasis occurs. One of the last things the late Dr Lynah did was to have established a roentgen-ray department at the Willard Parker Hospital, one of the largest hospitals in the country for the study of contagious diseases. I was asked to direct the work there. There were immediately a number of cases of children who had had postdiphtheritic stenosis of the larynx. Bronchiectasis was common, and one case particularly was interesting because the bronchiectasis was in the upper lobe. Dr Lerche is correct, I am sure, in saying that bronchiectasis occurs early in life following the infectious diseases.

Beginning this year at the Willard Parker Hospital, we hope to make roentgenograms of all patients as they come into the hospital and before they leave, possibly we can also establish a follow-up. In a year or so we will be able to report the results of that work.

DR LERCHE. I forgot to mention one thing, namely, that the lymphatics of the inferior half of the lower lobe do not drain into the tracheobronchial nodes but into preaortic nodes which may be of clinical importance.

# LIPOMAS OF THE MEDIASTINUM\*

EVARTS A GRAHAM, M D

AND

E R WIESE, M D

ST LOUIS

The tumors of the mediastinum which are supposed to be most common are readily recognized by the roentgen ray. They include the various neoplasms involving the mediastinal glands, substernal thyroid adenomas, aneurysms, dermoids and other tumors. In the case of the lipoma, however, a shadow is not revealed unless it is large. It has occurred to us, therefore, that fatty tumors may actually be much more frequent than the few references to them in the literature would indicate, especially since it might be easy to overlook them at postmortem examination unless they were unusually large. Their clinical importance lies in their ability to produce effects of pressure, and they should be considered as possible causes of symptoms in those cases in which there is perhaps an otherwise unexplained choking sensation, a recurrent laryngeal paralysis or similar condition. Our attention was attracted to these possibilities by a recent case.

## REPORT OF CASE

B N, a white man, aged 43, of strong physique, was admitted to Barnes Hospital because of a small mass in the lower right side of the neck. He had first noticed it about six months before admission. Shortly afterward, he began to have intermittent choking spells with dyspnea of short duration. A little later, attacks of pain occurred which began in the neck and traveled downward on the right side into the chest. The choking sensations seemed worse during the attacks of pain, and at these times he observed cyanosis of the finger tips. There had also been indefinite attacks of numbness of the right arm and of the right side of the chest. During the last few weeks, he had noticed hoarseness which at times was severe. The lump in the neck had gradually grown larger.

Examination revealed a soft diffuse swelling above the sternum, more on the right side than the left and apparently coming up into the neck from behind the sternum. This mass was movable, not tender, moved only slightly on swallowing and did not pulsate. Substernal dullness was not present on percussion. On forced inspiration, the mass came up higher in the neck. Laryngoscopic examination showed that both vocal cords moved, but the left seemed to override the right slightly. Roentgen-ray examination revealed nothing of importance except that there was an abnormal upward bulging of the right leaf of the diaphragm in its middle portion. There was no obstruction of the esophagus. Examinations of the urine and blood revealed nothing abnormal. The Wassermann reaction was negative. The pulse, temperature and basal metabolism were all normal.

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In the course of the deliberations in Chicago, negative pressure was declared to be the best adjuvant for safe operating within the thorax from a physiologic as well as a pathologic point of view, though positive pressure for the exclusion of a possible collapse of the lung also had its advocates. The hope was expressed that with further investigation this fundamental question would be definitely solved in the near future.

Soon a negative chamber was built in New York, and having been tested in animal experimentation, it was erected in the thoracic pavilion of the German Hospital, later renamed the Lenox Hill Hospital, of New York City. It permitted the changing at will from negative to positive pressure and vice versa, without the necessity of moving the patient, instruments and everything else from the inside to the outside of the chamber or vice versa, as had been necessary for such a change of pressure in the older chamber models. The New York chamber had been built in this way for the purpose of determining in as scientific a way as possible the relative clinical value for the patient of the two types of air pressure, negative and positive. The chamber also allowed the production of prolonged artificial respiration with the greatest ease, by simply moving a valve handle to and fro.

While this New York chamber was being experimentally constructed, tested and rebuilt and erected for clinical work, a number of new apparatus for positive pressure only were tried extensively. Conspicuous among them were Brauer's and Robinson's box, Brat-Schmeden's and Tiegel's mask apparatus—the latter surgeon proving as early as 1908 that 1 mm. of pressure of pure oxygen suffices to avoid the deleterious accumulation of carbon dioxide in the blood after acute collapse of the lungs—the Meltzer-Auer intratracheal insufflation and Branower's pharyngeal insufflation.

In consequence of the rapid evolution of thoracic surgery resulting from all of these new devices, the scientific investigation for which the New York negative chamber had been constructed was never carried out in a series of cases. Clinical observation in operations performed under positive pressure, with the employment of Tiegel's oxygen pressure apparatus abroad and intratracheal as well as intrapharyngeal insufflation in America, proved in phenomenally quick succession that such carefully conducted observations were not needed.

By this time the World War had begun, and it soon focused the attention of the medical profession at large on thoracic surgery. Surgeons returned from the front with the message that intrathoracic operations could be performed without apparatus for the control of air pressure. The experiences gathered during the war, however, could not shake the firm pillars on which the building of modern thoracic surgery had been erected. After repeated and thorough discussion, particularly in our association, it was resolved unanimously at our meeting



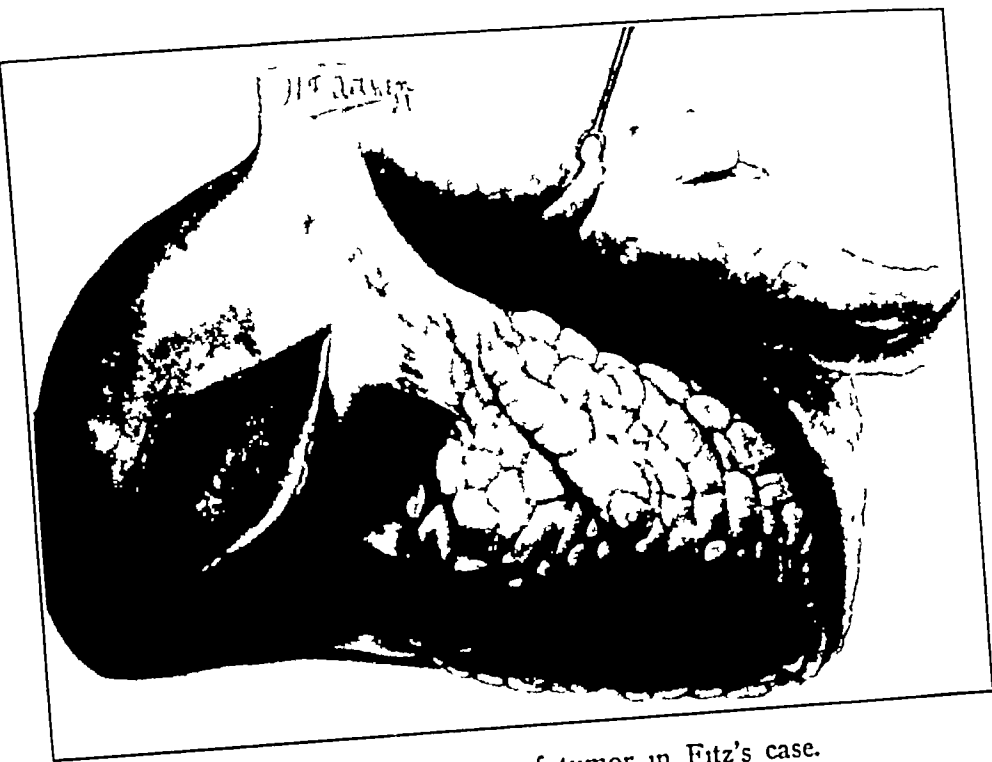


Fig 2—Appearance of tumor in Fitz's case.



Fig 3—Drawing made at operation in author's case

time, restored the heart action to such an extent that any other intervention became superfluous. On the other hand, when the hospital no longer had the negative chamber and the plus-pressure cabinet, I lost a patient with a large pulmonary lip-fistula and marked bronchiectasis of the left upper lobe, whose lung, because of repeated severe hemorrhages was being collapsed in stages. The patient died because we were unable to keep the mask on his face for the long period required. But it was again clearly shown that breathing pure oxygen under pressure with the mask in place restored the failing heart as long as it could be kept up.

Personally, I feel that the lack of such an apparatus at the Lenox Hill Hospital at the present time represents a defect in the armamentarium for the proper after-treatment in certain cases. I am pleased to add, however, that the chief of the division of anesthesia has in mind the construction of a breathing device of the type described.

From a broad point of view, thoracic surgery is today able to bring help whenever required. With the special operating room eliminated, with thoracic operations, like all others, performed in the general operating room and with acute pneumothorax overcome by simple means, every nook and corner within the chest can be safely reached, in one word, the thorax is as wide open for aseptic surgery as the abdomen has been for almost fifty years. There are no more pitfalls or unexpected snags to mar the results of the experienced surgeon's fascinating work.

The evolution of the principles of thoracic surgery is complete. It has reached a status of which surgeons the world over—and all nations have done their share in attaining this goal—may well be proud, this is an inspiring retrospect. What remains to be done is to study the details further and to work out to perfection methods for thoracic operations, as has been done for operations on any other part of the body.

Nothing contributes more to progress in any field than free discussion by the men interested. Our association was founded ten years ago solely for this purpose, and free and unlimited discussion at the annual meetings is an absolute necessity. A limitation to five minutes for each discussor seems inadvisable. We all want to learn from the most recent experience of our colleagues.

Now, what is the outlook for thoracic surgery in America with its vast areas and enormous distances? Patients chronically ill but transportable, will naturally not mind the distance, they will consult the experienced surgeon of their selection, as they have done heretofore. But what about these acutely ill, the large number of those injured by automobiles by train collisions and by accidents and explosions in factories, who have sustained internal injuries of the chest? And what about patients with fulminant inflammation, acute gangrene of the chest and other conditions for which they need prompt and adequate treatment lest they die? In the large cities with a multitude of

In 1887, Kronlein<sup>2</sup> reported a case in an infant, aged 6 months, in which the operation was performed by Langenbeck. A tumor presented, extending from the right axillary line to 3 cm beyond the left sternal edge and from two fingerbreadths below the right clavicle to the xiphoid cartilage. The tumor was exposed and found to continue into the chest through the third intercostal space by a pedicle. The pedicle was cut across and the external tumor removed. The child died of erysipelas, and autopsy revealed a rounded lipoma as large as a child's head, which was covered with a firm fibrous capsule and which filled the anterior mediastinum. In 1892, Gussenbauer<sup>3</sup> reported the case of a woman, aged 42, who presented a tumor at the upper border of the left breast, it was painless and at first was about the size of a nut. It grew steadily and three years later, the patient came to operation. A pedicle about twice the size of a finger extended into the chest through the second intercostal space. The intrathoracic portion was enucleated and removed. It was a little smaller than the outer tumor, about the size of a man's fist. The entire tumor was about twice the size of a fist. The patient recovered. In 1905, Fitz<sup>4</sup> reported before the Association of American Physicians a case of a man, aged 34, who died of acute pericarditis. At autopsy a mass of fat about the size of the head of a newly born infant, shaped like a pear, was found attached to the pericardium on the left side and continuous with the fatty tissue of the superior mediastinum. The mass was divided into lobules by connective tissue and projected into the inferior and anterior portions of the left pleural cavity. It was adherent to the diaphragm, pericardium, parietal pleura and the left lower lobe. In spite of the large size of this mass, symptoms ascribable to it evidently had not been present. In a discussion of this case at the same meeting, Ewing described a lipoma which had been found in the dissecting room in the body of a man who had died of acute lobar pneumonia. A large, lobulated mass of fat was found in the anterior mediastinum, this mass sprang from a pedicle which ramified in many directions and involved the pericardium, passed up along the bronchi, trachea and great vessels which it partly surrounded and apparently infiltrated the diaphragm. In all these places there were bands or small lobulated fatty masses. The main part consisted of five lobules, each about the size of a goose egg. Both lobes of the left lung were diminished in volume by these masses which were packed together in the lower part of the left pleural cavity. In 1923, Beyers<sup>5</sup> reported a

2 Kronlein Arch f klin Chir (supp) **21** 157, 1877

3 Gussenbauer Ein Beitrag zur Kenntniss der subpleuralen Lipome, Arch f klin Chir **43** 323, 1892

4 Fitz, R H Intrapleural Lipoma, Tr A Am Phys **20** 57, 1905

5 Beyers, C F Case of "Subpleural" Lipoma in a Child, Lancet **1** 283, 1923

So it is the hope, and seems to be the proper outlook, for thoracic surgery in America, that in every state of the Union the accidentally internally injured person will find nearby a well equipped hospital prepared to help at a moment's notice, where a condition will be diagnosed correctly and where patients with acute inflammatory conditions of the organs within the chest will be treated scientifically. This hospital should have at its disposal the able cooperation of specialists in bacteriology, radiology and peroral endoscopy of the bronchial system and of the esophagus.

The time will soon come when, in the absence of the chief of the surgical staff of the smaller hospitals, the house surgeon or the medical assistant must be able to recognize the increasing pressure of accumulating air and blood within the chest, for instance, in the presence of a broken rib (or ribs), a piece of which has pierced the lung and allows the entrance of air into the pleural cavity or into the mediastinum with each inspiration without giving it a chance to escape. In a short time, the increasing "pressure pneumothorax" will extinguish life. The air-tight introduction of a small rubber drainage tube through the cannula of a trocar, pushed into the chest, and its easy connection with a syphon bottle under the operating table and bed may help the patient through the gravest moments and may even save his life. The same result will be attained by the comparatively simple operative entrance into the chest between the ribs in order to stop an uncontrollable active hemorrhage and to mend the tear of a lobe of the lung, or the bronchus, then the typical air-tight drainage of the pleural cavity should be instituted for the first forty-eight to seventy-two hours.

These life-saving principles of thoracic surgery after acute injuries should be taught in all medical schools. Every medical man who lays claim to the title "surgeon" should be prepared to enter the thorax and follow up a stab wound or a shot wound of the chest through the diaphragm into the abdomen. This will often suffice when it is necessary to stitch, remove or drain an injured spleen or kidney, to close a wound of the stomach within the dome of the diaphragm or to deal properly with a wound at the convexity of the liver with the help of the thoracic entrance alone or by a combined operation.

It is unnecessary, before this Association, to enlarge further on what has just been said. The aim is to have every medical student taught the principles of thoracic surgery. Let the enthusiasm of youth be kindled for this fascinating chapter of medical science! Then a still larger proportion of patients with foreign bodies in the bronchi or the esophagus, accompanied by acute intrathoracic inflammatory conditions, who may become crippled for life or die in the absence of prompt competent treatment, will be restored to their normal physical and economic status, and many persons injured internally, who at present die, will be saved.

# DIAPHRAGMATIC HERNIA

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An increasing number of cases of diaphragmatic hernia are being recognized, and the condition is probably more common than even present records would indicate. The condition is of interest to the surgeon because operation is being performed in a larger number of cases with satisfactory results. Undoubtedly more cases will be considered surgical as the indications for surgical intervention and the technic of operative procedure become more definitely established.

Ambrose Paré is credited with having described the condition in 1610. He reported two cases of traumatic origin. Riverius reported a congenital case in 1698. Kirschbaum reviewed seventeen cases in 1755. Morgagni wrote a monograph on the subject in 1769. Sir Astley Cooper discussed the subject in 1824. Bowditch reviewed eighty-eight cases in the literature up to 1886. Ricolfi, in 1886, reported an operative cure of a stab wound of the diaphragm through which the omentum prolapsed. Naumann, in 1888, operated in the first case of diaphragmatic hernia in which the hernial contents did not prolapse through the thoracic wall. Marana, in 1893, operated successfully in a case of stab wound with injury of the stomach which was detected by the finding of gastric contents in the thoracic cavity. In the same year Amante successfully repaired a stab wound of the diaphragm.

The roentgen ray with opaque mediums to outline the abdominal viscera has proved the most valuable diagnostic aid in the recognition of diaphragmatic hernia. The technic of this diagnostic procedure was fairly well standardized by 1908. According to Arnsperger,<sup>1</sup> diaphragmatic hernia had not been recognized in life more than ten times previous to 1908. In 1912 Giffin<sup>2</sup> reported 690 cases of diaphragmatic hernia of which only fifteen had been diagnosed clinically. In 1915, Kienboeck,<sup>3</sup> in a review of German literature, noted records of only three cases of diaphragmatic hernia and one of eventration which had been diagnosed in life and confirmed at necropsy. The reported incidence varies greatly

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1 Arnsperger, quoted by Unger, A. S., and Speiser, M. D. Congenital Diaphragmatic Hernia, with a Report of Seven Cases with Autopsies, *Am J Radiol* **15** 135, 1926.

2 Giffin, H. Z. The Diagnosis of Diaphragmatic Hernia, *Ann Surg* **55** 388, 1912.

3 Kienboeck, R. Ueber Megengeschwüre bei Hernia und Eventration Diaphragmatica, *Fortschr a d Geb d Rontgenstrahlen* **21** 322, 1913-1914.

ligated, and the pericardium was exposed by blunt dissection, seized with clamps, brought forward and opened. Pus was forced out under great pressure for a distance of several feet. The pericardium was irrigated with saline solution, and rubber tissue drains were inserted into the pericardial sac. The immediate relief following operation was striking. The next day, however, there was a decided increase in the lung signs, and thirty-six hours after operation the infant died.

*Summary*—1 In this case the suppurative pericarditis was secondary to pneumonia.

2 A roentgenographic examination, about the sixth week of illness, showed a pericardial effusion. Aspiration of the pericardium by Dr. Dennett showed that the effusion was purulent. The infecting organism proved to be *Bacillus influenzae*.

3 Pericardiotomy was performed two days after the aspiration.

4 Relief was only temporary and death occurred about thirty-six hours after operation.

The report of the following case up to June 25 is modified from a statement by Dr. Adolph G. De Sanctis.

*CASE 2—History*—Lena C., aged  $3\frac{1}{2}$  years, was admitted to the babies wards of the New York Post-Graduate Hospital on June 14, 1922. This patient was referred to me by Dr. De Sanctis. The chief complaint was, according to the mother, an elevated temperature which had been as high as 104 F., and which had been continuous for two weeks previous to admission to the hospital. The family history was negative. The child had had measles, mumps and whooping cough. There was no history of diphtheria, scarlet fever, tonsillitis or rheumatism. She had been ill for two weeks prior to admission and had had a daily temperature varying between 100 and 104 F. The mother said that the onset followed a blow on the head with a stone. There was no apparent injury from the stone. Five days prior to admission she had had a generalized convulsion lasting twenty minutes but none had occurred since then. Her appetite had been poor, she had had one watery greenish stool daily, and had vomited a small amount occasionally. She had had a slight cough since the onset of her illness.

The important facts in the history were the elevated temperature and the history of the cough. There was no doubt that the fact that the child was hit on the head with a stone was a coincidence. The convulsion was probably due to the extremely high temperature at that time.

*Physical Examination*—The patient was a well nourished child and appeared to be acutely ill. Scars or evidences of external injury were not found on the scalp.

The teeth were in fair condition, the throat was slightly reddened and the tonsils were enlarged and cryptic. The neck was normal. The chest was symmetrical and respiration appeared to be equal on both sides.

The lungs were normal on palpation and percussion. There was a small area anteriorly just outside the left nipple, where the breath sounds were bronchial. Râles were not heard over any part of the chest. Posteriorly, the chest was normal.



On June 25, with the child in a semisitting posture on account of dyspnea, the operation was performed under local anesthesia. The left sixth costal cartilage was resected, the internal mammary artery ligated and the pericardium exposed without opening the pleura. The pericardium was seized with fine clamps and opened. Thick pus escaped under pressure. The remaining pus was aspirated with a suction apparatus, such as is used in operations on the throat. The pericardium was sutured to the wall of the chest. Drains were not used. Following evacuation of the pus, there was marked improvement in the patient's general condition. In order to secure good drainage, the child was made to lie face downward for a period of thirty minutes, every two or three hours. The patient cooperated well and gravity drainage of the pericardium was secured from the start. The wound healed completely in about one month.

On July 20, an electrocardiographic study was made. The time relations and deflections indicated that there was no heart block in any area. The auriculo-ventricular rate of the heart was 132 a minute, the rhythm, regular. There was no intermittence. The "T" deflection was inverted in lead II and flattened in lead III. This is seen only in abnormal hearts, but the significance is uncertain. The record is not typical of that of "congenital heart." If hypertrophy is present, both ventricles are equally affected, because the records do not show preponderance of either ventricle.

*Summary*—1 In this case the suppurative pericarditis was secondary to pneumonia.

2 Roentgenographic examination of the chest, on the twenty-second day of the child's illness showed a large pericardial effusion. Aspiration of the pericardium by Dr. De Sanctis on the same day showed that the effusion was purulent. Culture of the pericardial pus showed the infecting organism to be *Staphylococcus albus*.

3 Two days later, pericardiotomy was performed. The sixth costal cartilage was resected. About 750 cc of pus was removed by suction. The pericardium was not irrigated and drainage material was not placed in the pericardial sac. Postural treatment was depended on to accomplish drainage.

4 The wound healed completely in about one month. At the present time the child appears normal and healthy. There is, however, a slight systolic murmur of the heart, heard at the apex, but not transmitted to the back.

*CASE 3*—Max, S., aged 14, was admitted to the service of Dr. Shattuck at the New York Post-Graduate Hospital on Feb. 28, 1924, with a temperature of 105.6 F., respiration, 40, pulse rate, 140. Two days before the boy had had a chill, headache, sharp pain in the left side of the chest, cough and vomiting and had expectorated bloody sputum. A diagnosis of lobar pneumonia of the lower lobe of the left lung was made. The boy was profoundly toxic and critically ill for about two weeks. He was in the hospital for over two months and during the greater part of this time the course of his illness was stormy. Only the most important features of his illness are given here.

*March 1* Examination of the sputum showed influenza bacillus and type IV pneumococcus.

*March 10* There were signs of a pleural exudate and of marked increase in the total area of the heart. A roentgenogram showed an effusion in the left side of the chest and a large pericardial exudate.

*March 13* Thoracentesis was performed of the left side of the chest, and 130 cc of turbid serum withdrawn. The chest was aspirated again on March 13, 16 and 19. At the last aspiration, the fluid had become frankly purulent.



and bears a definite relation to esophageal hernia. About this period (11 mm) a physiologic alteration in the abdominal area takes place. The celom has not increased in size enough to take care of the rapid changes that are taking place within its walls and which are augmented by the descent of the septum. As Mall<sup>11</sup> states, "Since the liver grows downward and crowds upon the rapidly elongating intestine, the intestine must escape it if it has a chance and the coelomic space within the umbilical cord naturally receives it." This phenomenon, known as the physiologic umbilical herniation, provides a reservoir for the abdominal contents until the peritoneal cavity has grown sufficiently to store its own contents. The herniated intestine is restored to the abdominal cavity by the growth of the abdominal wall past the fixed mesentery of the intestines.\* This physiologic herniation starts at 11 mm, is well developed at 22 mm and starts on its way toward voluntary reduction at about 35 mm.

During this period of greater activity in the abdominal celom, the diaphragm is incompletely formed, and the hiatus pleuroperitonealis is patent. The closure takes place on the right side first at about 17 or 18 mm and on the left side at about 19 or 20 mm. The left side of the liver has largely disappeared, and the whole organ has rotated to the right and fused with the right wall of the body, protecting to a great extent the right half of the diaphragm and probably aiding its more rapid completion. The stomach has reached its permanent site below the diaphragm before the left half of the diaphragm is closed. Therefore the hiatus pleuroperitonealis patent on the left side is in direct contact with the rapidly forming and constantly changing hollow viscera during this period of physiologic umbilical herniation.

It would seem that this time of the incomplete closure of the diaphragm in relation to multiple rapid changes which are taking place in the embryo is of great importance in the preponderance of left-sided congenital defects. To recapitulate, these changes consist of (1) the occurrence at this time of the normal physiologic umbilical herniation, (2) the patency of the hiatuses connecting the peritoneal and pleural cavities, the left closing last, (3) the sudden descent of the diaphragm, which is considerably in advance of the descent of the stomach, (4) the shift of the liver to the right because of anchorage and the degeneration of the left lobe from vascular change and pressure, (5) the presence of hollow mobile viscera on the left side, (6) the elevated position and smaller size of the left lung, (7) the rotation of the stomach to the left and (8) the presence of bursae at the esophageal opening.

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11 Mall, F. P. *Manual of Human Embryology*, Philadelphia, J. B. Lippincott Company, 1910-1912, vol. 2, p. 321.

it may complicate a distant focus of infection, such as an osteomyelitis, and it may be part of a general sepsis. Such being the case, the prognosis will depend, to a considerable extent, on the duration and severity of the original disease to which the pericardial suppuration is secondary. If my three cases are added to the ninety-nine cases mentioned in Pool's report, in which the patients were operated on for suppurative pericarditis, there have been forty-seven deaths and fifty-five recoveries. Some of the patients who recovered have shown a crippled condition of the heart due to intrapericardial or mediastinopericardial adhesions. The degree of myocardial degeneration also has a most important bearing on the ultimate prognosis in these cases.

I resected the fifth costal cartilage in my first case, in my second case, the sixth costal cartilage, and in my third case, the sixth and seventh costal cartilages. If I have another case, I shall make a hockey-stick incision, beginning at the fifth cartilage and progressing down along the left edge of the sternum and along the seventh cartilage, then I shall resect all three of these cartilages. This is the method proposed by Pool, and it impresses me as the best yet suggested. I believe that a local anesthetic is the anesthetic of choice, but if for any reason a general anesthetic is demanded, my preference would be for ethylene gas. Removal of the pericardial pus by suction rather than by irrigation at the time of operation, seems to be a step in the right direction. Postural treatment to secure drainage is also an important measure. There should not be any fixed rules about irrigation of the pericardium or about the placing of drainage material in the sac. Each patient should be treated according to individual indications.

#### ABSTRACT OF DISCUSSION

DR WYMAN WHITEMORE, Boston. The subject of pericarditis is of great interest to all thoracic surgeons. One great trouble is that few men treat many of these patients. In fact, I do not know of any one who has had any considerable number of these patients. There are certain points that interest me. The first is the diagnosis. As Dr Peterson has said, the diagnosis is often missed, this was particularly true before the roentgen ray was used. I think that now physicians and thoracic surgeons probably use the roentgen ray often and early in these cases, and that the diagnosis is not missed as frequently as it used to be. The second point is, as Dr Peterson has said, that this condition is always secondary to an infection elsewhere.

The third point that has always interested me, is the luck that the patient and surgeon have in these cases. By that I mean, suppose that a patient has pneumonia and a small empyema, which is drained, pneumococcic pericarditis develops. This patient has as good a chance to get well as the patient who has a streptococcic septicemia and develops streptococcic pericarditis. An operation in a case of streptococcic pericarditis does not offer the patient any hope of recovery.

I have had four cases. One was a pneumococcic case in which the patient recovered, this patient had an empyema and then a pericarditis, which was

interest that in seventeen of these cases the diagnosis of hernia of the cardiac end of the stomach through the esophageal opening was made by means of the roentgen ray. This is the most common type of hernia that occurs in adults, as it is shown in the cases reported.

In twenty-seven cases, herniation of the abdominal viscera into the thorax was the cause of the complaint, and operation was performed.



Fig 2—Diaphragmatic hernia with almost half of the stomach above the diaphragm through esophageal opening

Seventeen of the patients were males, and ten were females. The youngest patient was 5 years and the oldest 72 years. The age incidence in decades was from 1 to 10 in two cases, from 11 to 20 in three, from 21 to 30 in four, from 31 to 40 in three, from 41 to 50 in six, from 51 to 60 in eight, from 61 to 70 in none and from 71 to 80 in one.

into direct contact with the pericardium at this point by fluid lying behind the heart. Aspirations in the fifth left interspace just inside the left border of dulness should therefore follow a negative aspiration. At the sternal margin, I should regard the latter point the preferable one in all cases if it were not for the possibility of pleural contaminations in case the fluid is infected and the pleura not adherent.

In a few cases, in which I have failed to find fluid elsewhere, I have obtained it by aspiration in the fifth interspace at the right sternal margin.

There is no doubt that nearly all cases of pericardial effusion are secondary to infection elsewhere. I have had one patient with sterile tuberculous effusion from whom, however, 2 liters of pus were obtained. When the case came to necropsy, a few months later, examination failed to reveal any trace of primary infection, even in the glands. I reported this case as one of primary tuberculous pericarditis.

Even though the condition is secondary and the mortality high I believe that we should make every effort to establish the diagnosis early and to drain for all infected effusion. I am much interested in Dr. Peterson's method of drainage, but I have been so impressed by the value of a surgical solution of chlorinated soda in cases of empyema that I prefer to take my chances with the suction and irrigation drainage that its use involves. I had one patient with double streptococcic empyema and purulent pericarditis who apparently would have recovered following simultaneous irrigation of all cavities had he not died of a sudden hemorrhage into the pleural cavity on the tenth day.

DR. WILLI MEYER, New York. Since we have the roentgen ray, the enlargement of the heart's shadow is clearly seen, and there is also the possibility of finding it by percussion. We will thus be enabled to establish the diagnosis without much difficulty. No doubt these patients with a larger effusion in the pericardium suffer a great deal, and if there is even a suggestion of an effusion, it is an easy matter to ascertain whether this is present.

I thoroughly agree with what Dr. Hedblom said and also with the previous speaker. I would always favor aspiration in the fourth or fifth interspace close to the left side of the sternum, where one can be sure not to injure the internal mammary artery with the needle. If the needle usually is directed slightly upward and outward, it will be possible to strike the effusion in the majority of cases.

In 1908, I operated on a tuberculous patient with chronic pericarditis. He had been in the medical division of the Lenox Hill Hospital quite awhile and suffered intensely. Aspiration was performed by the method I have just mentioned, a bloody effusion was found—a dark fluid, which showed the decomposition of blood under the microscope. It came out easily in large amounts. An operation was performed and more than 2 quarts of fluid were found in the sac. Many of you have read the article on chronic pericarditis in 1904 or 1905, published by the late Professor Curschmann of Leipzig. He cited cases in which more than 3 quarts of fluid had been removed from the sac. That is easy to understand if one remembers that the pericardium touches the esophagus posteriorly. If a person has a large chest this mediastinal sagittal diameter is long, and so frequently the greater part of the fluid is behind the heart, so that the aspiration or evacuation of more than 2 or 3 quarts of fluid from the pericardium is possible and easily explained.

In our case aspiration was done first, then the fluid reaccumulated. After this, we decided to operate. I have not had time to look up the histories in my old cases, so I will not give you the details but only say that a large

diagnosed clinically as ulcer or disease of the gallbladder. The most common symptoms noted by Giffin were (1) pain in the epigastrium and chest immediately after eating, (2) paroxysms of smothering without apparent cause and (3) vomiting without premonition. Healy<sup>13</sup> gives as the principal symptoms (1) substernal pain, (2) vague gastric



Fig 4—Traumatic diaphragmatic hernia following gunshot wound. A bullet may be seen in left flank at the level of the eleventh rib. Almost the entire stomach is in left thoracic cavity.

distress and (3) vomiting in the morning without hyperacidity. The cardinal symptoms given by Oden<sup>14</sup> are (1) epigastric pain immediately

13 Healy, T. R. Symptoms Observed in Fifty-three Cases of Nontraumatic Diaphragmatic Hernia, *Am J Roentgenol* **13** 266, 1925.

14 Oden, R. J. E. Diaphragmatic Hernia, *Ann Surg* **78** 660, 1923.

would put my fingers into the pericardium, as I do in the pleural cavity, make a puncture farther outside with the knife, introduce the tube for air-tight drainage into the sac, under the guidance of eyes and fingers, and close the original incision. Then I would have the combination of open incision and air-tight drainage, if the various tissues, muscles, fascia and skin are carefully sutured just over the entrance of the tube into the pericardium and the drainage tube properly secured, the method will be the same as the one that has been tested successfully in air-tight drainage of the pleura in cases of empyema.

DR FREDERICK T LORD, Boston. I should like to call attention to certain aspects of the diagnosis in these cases. The infrequency of pain as a symptom of inflammation of the pericardium has long been recognized and has until recently not been satisfactorily explained. Capps of Chicago has shown by experimental mechanical irritation that the interior of the pericardium is insensitive at all accessible points except in the region of the left inferior aspects of the sac. He ascribes the sensitiveness of this part to irritation of branches of the phrenic nerve. Judging by these experiments, the infrequency of pain in the presence of pericarditis may be attributed to absence of a sense of pain over the greater part of the pericardium. Absence of pain should not be taken as an indication of absence of pericarditis.

In the discussion, reference has been made to the presence of posterior accumulations of pericardial fluid, and this is another source of error in the diagnosis. When the heart becomes adherent to the anterior part of the pericardial sac, fluid may accumulate for the most part posteriorly and compress the lung in this region. The most significant physical signs of pericardial effusion may then be found in the left side of the back, and it is common in such cases to be able to demonstrate in the region of the left scapula an area of dulness with bronchial breathing, egophony and increase in the speaking and whispering voice and diminished tactile fremitus.

Roentgen-ray examination also furnishes important evidence of pericarditis with effusion. The shadow of the heart is triangular, and the sides of the triangle are straighter than normal as a result of obliteration of the indentation on each side at the junction of the auricles with the mediastinum, and on the left at the junction of the auricle with the ventricle.

DR N W GREEN, New York. The discussion and the reports of Dr Peterson's cases have been stimulating and impressive. I have had limited experience with cases of effusion of the pericardium, but the discussion Dr Whittemore brought one or two points to my mind, one of which was that when a patient has a streptococcal infection of the blood, the physician considers the case hopeless. A streptococcal infection of the blood predicates a blood-borne infection, and it seems to me that one should look for infection of the accessory sinuses, which in cases of diseases of the ear are often followed by pneumonia and sometimes by *Streptococcus hemolyticus* infection of the blood. I believe that it would be a good plan to determine whether there is any thrombosis or lateral thrombus in the jugular vein. If one could get rid of the primary source of the infection of the blood stream I do not think that *Streptococcus hemolyticus* infection of the blood would necessarily indicate a fatal outcome. I have had experience in one case of that kind, and the course of the disease was very much as I have outlined, first an infection of the ear, then of the mastoid, then in the jugular vein and then pneumonia. The patient did not have pericarditis, but a *Streptococcus hemolyticus* infection of the blood.

The inconstancy of these symptoms is undoubtedly produced by the varying site of the hernial opening and the difference in the degree of functional adjustment of the thoracic and abdominal viscera. It is evident that diagnosis by means of the history alone may be difficult,

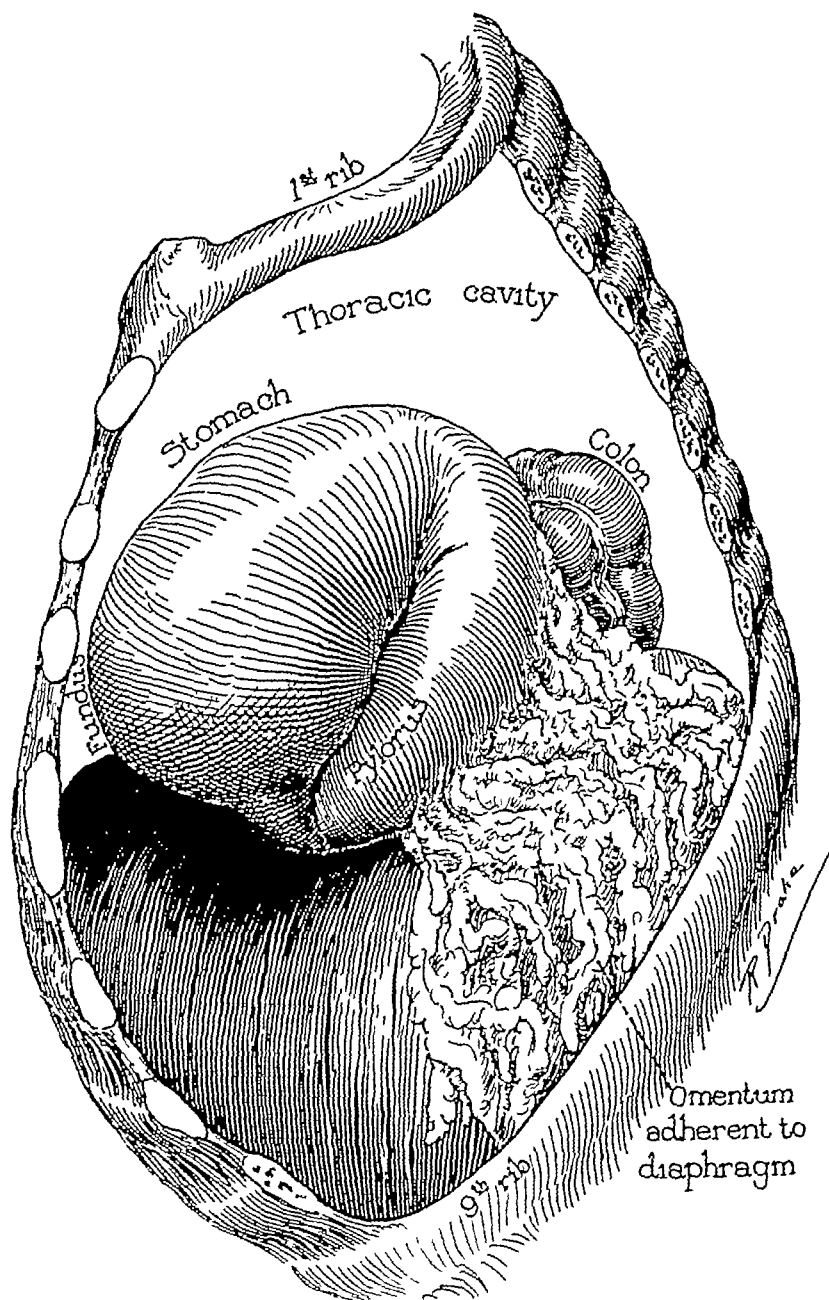


Fig 6—Left diaphragmatic hernia. Almost the entire stomach and a portion of the colon are in the left thoracic cavity. The omentum is adherent to the diaphragm and the under surface of lung.

however, such diagnosis is important and when possible, will obviate useless treatment. Because of the vague symptoms simulating some thoracic or abdominal disease, of which disease of the gallbladder and of the stomach are most common, operation may be advised. Diaphragmatic

could not be stopped. The cause of this bleeding remained obscure, although autopsy was performed. The only thing the pathologist suggested was that the motion, the friction between the heart and the pericardium, both being granulating surfaces, had the effect of continuously brushing off the apexes of the granulations. It seemed unusual. I had never seen it described and had never heard any one speak of it. The patient was not given a transfusion of blood. This was a long time ago. Clinically, the condition resembled hemophilia, it may be, however, that this resulted from some alteration in the blood brought about by scarlet fever.

The second patient had a large suppurating pericardial sac which was opened under local anesthesia and drained with protective tissue. The sac was irrigated daily. The sac became clean, but the pus accumulated rapidly behind the heart. A little later, the patient was treated by the instillation of mercurochrome-220 soluble, and the interesting fact was that in two or three hours after a dressing, when we had cleaned the pericardial sac the patient began to have a free discharge of pus. At autopsy, an apical tuberculous cavity was found with a sinus running from it to the suppurating pericardial sac, we had been dealing with a secondary type of pericarditis and of a variety I have never seen described.

DR DEW ANDRUS, Cincinnati. I want to say only a word about two cases we have had in Cincinnati. One of these patients had an abscess in the posterior portion of the pericardium. He was an Italian ex-soldier and had been shot in the back of the neck, a piece of tunic becoming embedded in the tissues. Before he came to us, he had had an abscess on the right side of the neck which was healed at the time of admission. Following a stay in the hospital for tuberculosis, he was brought to the general hospital with the diagnosis of abscess of the lung posterior to the heart. Dr Heuer approached it from the side in the posterior axillary line, and to his surprise found that it was not in the lung, but in the pericardium. The nature of the infection was not definitely determined. Subsequently, the patient developed an abscess in the groin, and after repeated roentgenograms, we discovered a collapsing lesion of the upper lumbar vertebra. Drainage of a lumbar abscess yielded the typical sulphur granules and ray fungi.

The other case was that of a boy, about 18, who was stabbed over the sternum with a knife. His wound was closed before he came to the hospital. Subsequently he developed shortness of breath, etc., which pointed to a mediastinitis. A roentgenogram revealed  $1\frac{1}{2}$  inches (3.77 cm) of knife blade broken off and buried in the sternum. Dr Heuer resected a portion of the sternum and costal cartilages, removing the knife blade, and found a suppurative pericarditis. The boy pursued a course similar to Dr Miller's patient having repeated small hemorrhages from the pericardium, which we felt were due to grating of the granulations with the pulsations of the heart. Despite repeated transfusions, the patient subsequently succumbed to severe secondary hemorrhage.

In the children who come in with coincident empyema, pneumonia and pericardial effusion, we have found it useful to increase the margin of safety. Decrease the load on the heart by giving these patients oxygen intranasally. Sometimes, even when they are not cyanotic, the administration of oxygen will make the breathing easier and reduce the load on the heart.

DR HUGH AUCHINCLOSS, New York. Dr Peterson's cases are noteworthy and most encouraging. Our experience with suppurative pericarditis at the Presbyterian Hospital has been chiefly with adults. The first patient who recovered was a child, the case was reported a number of years ago by



hernia may be discovered by exploration of the diaphragm during an operation for some other condition, particularly an upper abdominal operation, if disease of the gallbladder or stomach is suspected but not found. During the last year one esophageal hernia was found during an operation in a case with an indefinite history of cholecystitis in which the stomach had not been examined roentgenologically prior to operation.



Fig 8—Diaphragmatic hernia with about one third of stomach herniating through the esophageal opening, large perforating gastric ulcer high on the lesser curvature of the stomach

#### TREATMENT

The treatment in cases of diaphragmatic hernia in which the symptoms are mild and there is no obstruction, may be medical. Many patients go through life without sufficient symptoms to warrant operative intervention. In chronic cases with attacks of incarceration or obstruction

for drainage. Drainage through the anterior wall of the chest is easy to perform under an anesthetic. The closed system of drainage could be established with the pericardial sac draining into the pleural sac and then out. The anterior drainage could then be established at any time under local anesthesia. Drainage along the straight sinus is another problem. Accumulations have been seen on the other side of the heart. It seemed in the last case I had that accumulations of pus were found in the place at which the pocketing appeared as well as behind the heart. In my case in which the method of open drainage was employed, we used a surgical solution of chlorinated soda (Dakin solution), and placed the finger under the heart and a catheter straight around it, so that the catheter came up around the upper margin. It was possible to keep that part clean by drainage suction.

DR. PETERSON. The diagnosis in these cases of suppurative pericarditis is not as simple as is generally supposed. The roentgenologist if I recall correctly, made the diagnosis in all three of my cases. The roentgenogram is the most valuable aid in settling the question of diagnosis.

I feel that Dr. Hedblom's case of "primary" pericarditis is open to question. I merely suggest that it might have been one of tuberculous origin, as I cannot conceive of any case being primary.

I feel that the prognosis, as I said in my paper, depends largely on the duration and severity of the original infection to which the pericarditis is secondary. The mortality rate will be relatively higher in infants than in older subjects, just as it is in the empyema of infancy.

I want to thank Dr. Lilienthal for answering the question about closed drainage of the pericardium. I do not see that one can liken the drainage of the pericardium with drainage of the pleural cavity. Not only is the physiology different but the physics to be considered in the former is also different. I cannot see any great advantage in the closed method advocated by Dr. Whittemore and approved by Dr. Meyer. I feel, however, that postural drainage is a step in the right direction.

were employed, the type depending to some extent on the site of the opening in the diaphragm, as far as could be determined by roentgenologic examination. If the opening was anterior, the abdominal approach was used, and if posterior, the thoracic approach.

Nineteen of these cases have previously been reported by Giffin, Balfour<sup>16</sup> and Hedblom,<sup>17</sup> who made a complete review of the cases in which operation was performed up to 1925, I shall not include these cases in this report.

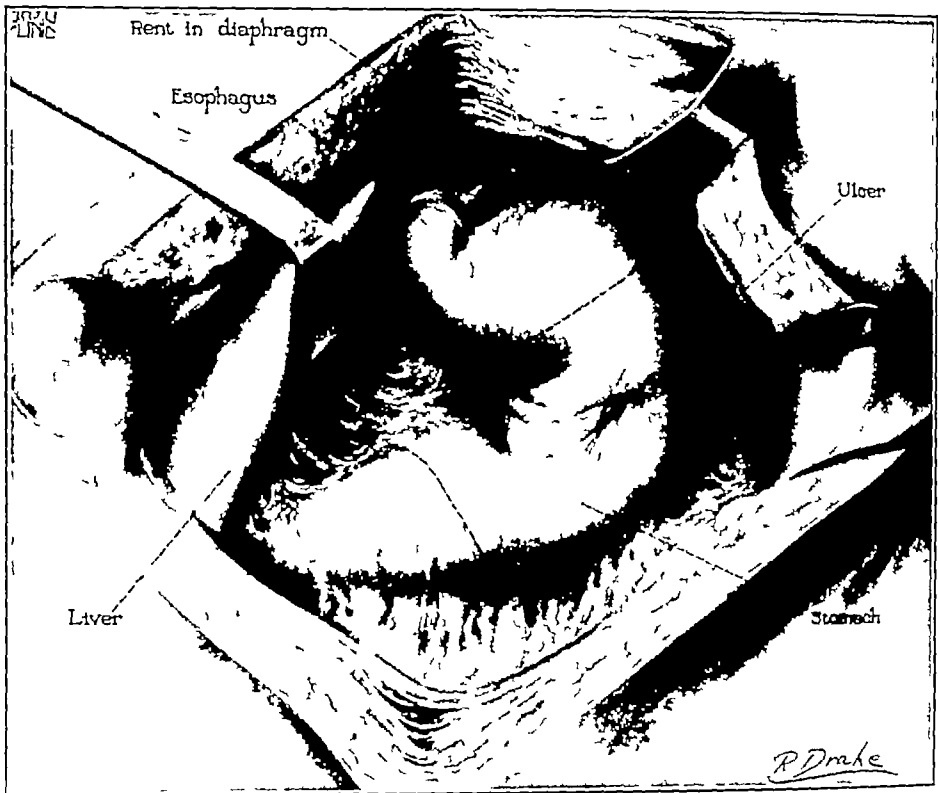


Fig 10—Exposure of cardiac end of stomach after reduction from hernial sac. A large perforating gastric ulcer is shown high on the lesser curvature of the stomach, about 7.5 cm. from the cardia and a large hernial opening just above and to the left of the esophagus. The dotted lines outline the area of gastric resection.

In the last two years eight patients have been treated surgically. In five of these there was no history of injury. In three cases operation had been performed previously for the same complaint.

16 Balfour, D. C. Nonstrangulated Diaphragmatic Hernia due to Indirect Injury, *Ann Surg* 63:78, 1916.

17 Hedblom, C. A. Diaphragmatic Hernia, A Study of Three Hundred and Seventy-eight Cases in Which Operation was Performed, *J A M A* 85:947 (Sept 26) 1925.

The systolic blood pressure was 150, diastolic, 85 Dilated veins were not seen on the thorax, and cyanosis was not present

Operation was performed under local infiltration anesthesia with procaine hydrochloride A collar incision was made and a lipoma about twice the size of a hen's egg was found lying beneath the sternothyroid and the sternocleidomastoid muscles It lay next to the right lobe of the thyroid gland, which seemed normal, and it extended downward into the anterior mediastinum for a distance of about 4 cm It was removed without difficulty by pulling it upward in much the same manner in which a substernal thyroid is removed The only muscle cut was the platysma Closure was made without drainage. Within a few hours after the operation the hoarseness had disappeared, and the patient stated that the dyspnea was not present He was discharged one week after the operation Six weeks later he was seen again following an attack of acute cholecystitis Hoarseness or dyspnea had not been present since the discharge He would not consent to an operation on the gallbladder

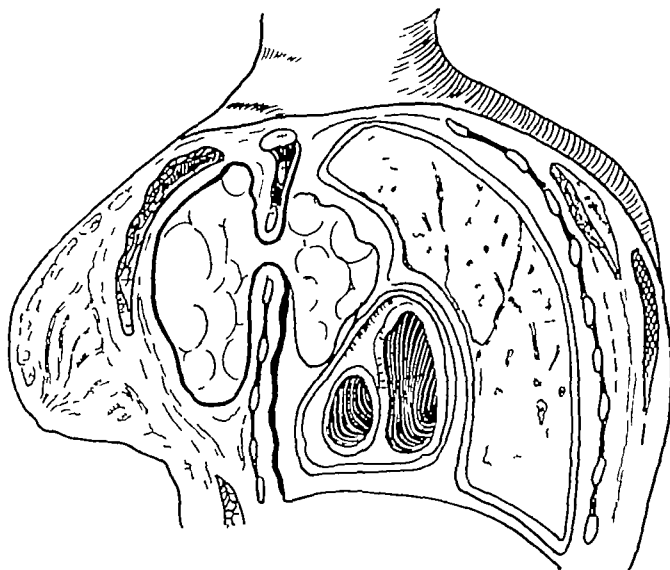


Fig 1—Diagram in Gussenbauer's case

After removal, the tumor was found to measure 9 by 5 cm On microscopic examination, it proved to be a simple lipoma

This case, therefore, was one of lipoma of the anterior mediastinum which caused sufficient pressure to produce hoarseness, dyspnea, cyanosis and possibly a partial paralysis of the right leaf of the diaphragm by involvement of the right phrenic nerve

The few instances of lipoma of the mediastinum which we could find recorded in the literature show only two other cases besides our own in which an operative removal was carried out successfully This is probably to be explained by the fact that most of the other cases occurred during the early days of antiseptic surgery In some of the reported cases, the tumor was limited to the mediastinum, in some it occupied the pleural cavity also, while in others it was located both subcutaneously and in the anterior mediastinum In all only nine cases

In one case the gallbladder was removed for gallstones at the time of repair of the hernia, and in one case the pyloric four fifths of the stomach was resected for a large perforating ulcer high on the lesser curvature of the stomach. These lesions were undoubtedly partly responsible for the symptoms (figs 8, 9, 10, 11, 12 and 13)

I prefer the abdominal approach in most cases. The herniated abdominal viscera can be brought under direct observation, and any injury that may be present in traumatic cases can be more readily

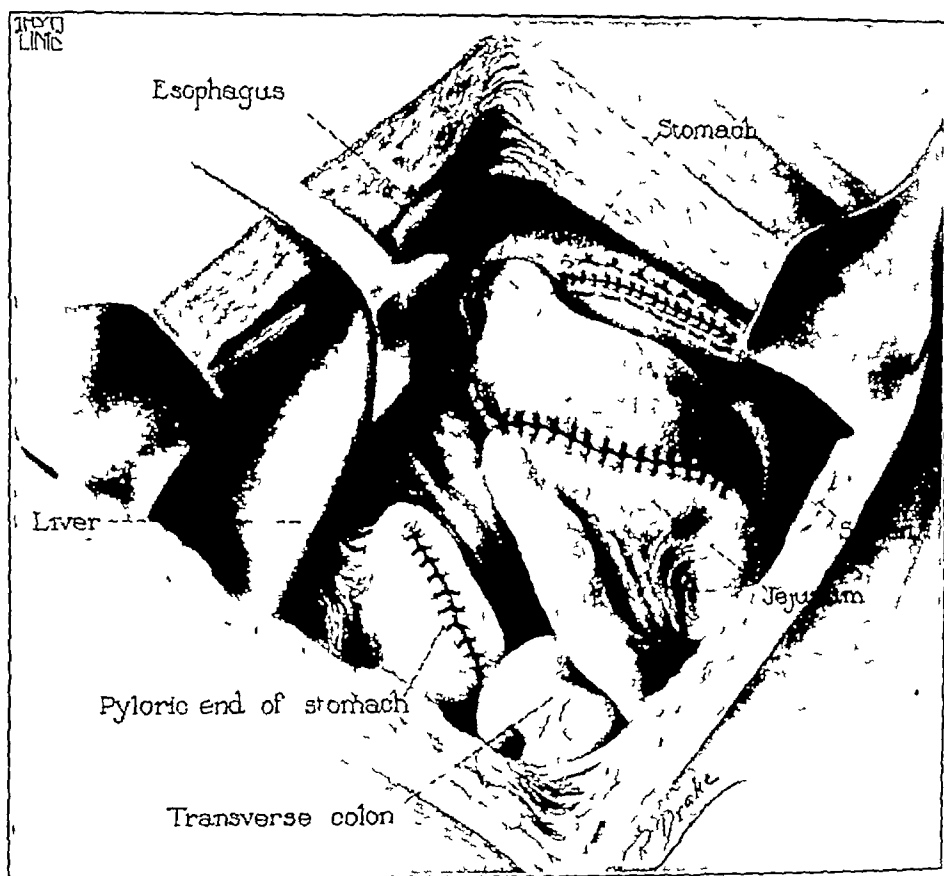


Fig 12—Closure of hernia opening in diaphragm with interrupted linen catgut sutures, resection of four fifths of the stomach, anticolic anastomosis of cardiac end of the stomach to the jejunum with closure of pyloric end of the stomach

repaired. There is no danger of injury to abdominal viscera during closure of the hernia. There is less deformity following operation, and the risk of the operation and the chance of postoperative complications are probably less. The abdominal approach permits exploration of the abdomen for other associated lesions which may be the cause of part of the symptoms. These lesions may be surgically treated at the same time if it is thought advisable. If the patient's condition does not permit

including our own, have been reported. Probably the condition is much more frequent than this small number of cases would indicate. There are several instances of intrapleural lipoma developing apparently from the subpleural fat, but they are not included in this report. The case described by Czerny<sup>1</sup> is an example of this.

In his classic treatise on pathologic anatomy in 1856, Cruveilhier stated that during an operation for the removal of a lipoma on the



Fig 4—Appearance of specimen after removal in author's case

front of the sternum, several prolongations were observed to continue into the anterior mediastinum. Most of these were withdrawn and cut off. The patient died of suppuration of the anterior mediastinum. Cruveilhier also mentioned that Morel-Lavallier removed the superficial portion of a lipoma, which continued into the anterior mediastinum, from the sternal region. The mediastinal portion was not disturbed.

<sup>1</sup> Czerny. Exstirpation eines kopfgrossen subpleuralen lipoms. *Wien med Wchnschr* 25 156, 1875.

combined method I have not found this necessary, but undoubtedly there are cases in which a satisfactory result cannot be secured in any other way

Gastric lavage should always be carried out just before operation and the tube left in the stomach or inserted after the abdomen is opened. This not only relieves the stomach of gas and thus aids in the reduction of the hernia, but also helps to determine the position of the cardia, this may be helpful in cases of esophageal hernia with adhesions and permits more accurate closure of the opening.

In seven of the cases the hernial opening was closed with chromic catgut reenforced with linen sutures. In one case the defect in the diaphragm was so extensive that closure was impossible, and the stomach was sutured to the abdominal wall.

There were no deaths, and convalescence was uneventful in all cases, except for minor complaints. The results, as shown by replies to recent questionnaires, are satisfactory, but some are too recent to be considered final. The most recent operation was performed three and one-half months before this paper was written. Four patients say that their symptoms have been completely relieved. The hernia was of traumatic origin in three of these. The fourth patient did not give a history of injury, and gastric resection for ulcer high on the lesser curvature of the stomach was performed as well. Two patients continue to have moderate gastric symptoms without evidence of recurrence four months and six months, respectively, after operation. In the case in which part of the diaphragm was absent and the stomach was sutured to the abdominal wall, relief has been only partial. In one case the hernia and symptoms recurred two months after the operation.

#### SUMMARY

The embryonic formation of the diaphragm predisposes to herniation at certain sites.

The symptoms of diaphragmatic hernia are varied, and clinical diagnosis is difficult without the aid of roentgenologic examination. Obscure upper abdominal symptoms demand roentgenologic examination of the diaphragm. Roentgenologic examination is often helpful in determining the site of the hernial opening. When the diaphragmatic hernia produces mild symptoms without incarceration of viscera, the patient may be kept under observation and medical management, but progression of symptoms calls for operation. Definite attacks of obstruction due to incarceration or strangulation of abdominal viscera demand operation.

The operative approach may be thoracic, abdominal or combined abdominal-thoracic, but the abdominal is usually preferable or the com-

case of a boy, aged 22 months, from whom he successfully removed a lipoma of the anterior mediastinum. There was a painless swelling in the front of the chest, which had grown steadily. The tumor was overlying the fifth, sixth and seventh costal cartilages. It had a lobulated surface and was adherent to the adjacent tissues but not to the skin. At operation an incision was made parallel to the sixth rib, and a fatty mass was found passing through the sixth intercostal space into the thoracic cavity. The sixth and seventh costal cartilages were resected, and a circumscribed fatty tumor was easily removed. Recovery was excellent. Microscopic examination of the mass showed it to be a simple lipoma. In 1925, Lemon<sup>6</sup> reported the case of a man, aged 46, who had dyspnea, swelling of the neck, cough, loss of weight, tumor in the left supraclavicular fossa, dulness over the upper sternum and distant breath sounds over the chest. Two biopsies were performed, the first of which was said to show an osteochondrolipoma and the second a lipoma. The patient weighed 221 pounds (100.2 Kg). The veins in the upper part of the body became dilated. Vertigo, somnolence, dyspnea, cyanosis and edema developed, and the patient became gradually worse. At autopsy a lipoma of the anterior mediastinum was found which was adherent to the trachea, aorta and right lung.

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6 Lemon, W. S. Lipoma of Mediastinum, *M. Clin. N. Amer.* 8:1247, 1926.



but covered by the liver anteriorly, was a large opening, a congenital defect of the diaphragm, through which portions of the gastro-intestinal tract had slipped into the thoracic cavity. In pulling further, we could slowly get a good portion of the intestines into the abdomen, but at the same moment some fecal matter escaped. I was extremely sorry that I had decided to start the operative procedure by way of the abdomen. With such a large portion of intestines in the thoracic cavity, the lung had to be compressed materially on that side for a long time. With 1 mm of oxygen pressure, one could have overcome any difficulty so far as a large opening in the chest was concerned. I should have made an intercostal incision and determined the condition. I could have seen it easily because a constriction of the middle of the transverse colon was causing the trouble. There was a clear local gangrene at this place. The primary intercostal incision would have been the better surgical procedure. After I had seen that there was a suppurative condition, I could have worked from above and below.

I have drawn a number of lessons from that case in addition to realizing the necessity for gastric lavage. I would never advise starting with an abdominal incision in a complicated case of diaphragmatic hernia. There is no harm in performing an exploratory thoracotomy. Had I have done so, I would have found the gangrene of the intestine and the hernial aperture at once, which was utterly impossible by way of the abdomen, because the right lobe of the liver was lying in front of it.

From a technical point of view, I would say as in so many other cases, that one must consider the individual case, as was emphasized in a number of other thoracic diseases.

Dr Harrington's eight cases make a wonderful series for one man to observe in such a comparatively short time, but he is working at the Mayo Clinic with its unlimited material. All his patients were operated on by way of the abdomen, and every patient has recovered, which speaks for itself. Yet I would say again, let us consider each case by itself, and when there seems to be a great deal of complication let us start the operative procedure by way of the thorax. Personally, I would then add an abdominal incision, so that I could see how I could replace the abdominal organs and secure them with sutures before the hole in the diaphragm was closed.

DR TRUESDALE, Fall River, Mass. Dr Harrington has demonstrated in a picturesque and practical manner those developmental deficiencies in the diaphragm that may be conducive to the occurrence of hernia. He has shown, too, that the stomach is more often involved in cases of hernia than any other of the abdominal viscera. When the stomach passes through the opening in the diaphragm, it can pass back and forth, and unless it is markedly constricted, it can be relieved. If a portion of the stomach has passed through the diaphragm and it becomes constricted, a stomach tube cannot be placed in that portion of the diaphragm which is above the constriction.

The stomach never becomes strangulated, because there is great elasticity to the hernia ring. When it fills with gas the pressure expels the contents below the diaphragm and thus empties. To prepare the patient for operation by washing out the stomach, as Dr Harrington describes, is the best policy, without a question. It is seldom if ever necessary to operate for hernia of the stomach, as an emergency measure.

On the other hand, that type of case which involves the small intestines and the transverse colon, which, as the statistics of Dr Harrington and Dr Hedblom have shown, is nearly 50 per cent of all cases, often presents the picture of acute obstruction.

Rowlands<sup>4</sup> found records of two cases in Guy's Hospital, London, from 1856 to 1920. Cruickshank<sup>5</sup> discovered two cases in a series of between 1,700 and 1,800 necropsy examinations, Rendich<sup>6</sup> reported two cases out of 5,033 clinical examinations at Bellevue Hospital, New York, Macmillan<sup>7</sup> found but three cases in 15,000 roentgenologic examinations at United States Army General Hospital No. 1, Beclere,<sup>8</sup> in 5,000 roentgen-ray examinations, found two cases, Morrison<sup>9</sup> reported forty-two cases of 3,500 gastric cases studied, and Carman,<sup>10</sup> in 1924, gave the ratio in the Mayo Clinic of 1:18,000.

#### ANATOMY

The diaphragm is a single independent dome-shaped muscle arising from the circumference of the lower part of the thorax and when normally formed completely separates the abdominal and thoracic cavities. The muscular structure of the diaphragm in the adult person is divided into three portions according to their origins, the sternal, the costal and the lumbar. The sternal is the weakest of these portions and the lumbar the strongest. All three portions are inserted into the margin of the central tendon. The sternal portion consists of a few slender fasciculi arising from the posterior surface of the xiphoid cartilage. There are muscular deficiencies on each side of the cartilage filled with areolar tissue and covered with pleura and peritoneum through which the superior deep epigastric vessels pass. These deficiencies are called the foramina of Morgagni or Larys' spaces. The costal portion forms the main part of the dome of the diaphragm and arises by broad bands of muscle from the lower six costal cartilages and from the eleventh and twelfth ribs, interdigitating with the transversalis muscles. This portion covers the greatest area. There are often areas devoid of muscle tissue between the individual bands that arise from the wall of the chest. The lumbar portion arises from the

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4 Rowlands, E. R. B. A Case of Diaphragmatic Hernia, *Guy's Hosp. Gaz.* **34** 426, 1920, Diaphragmatic Hernia, *Guy's Hosp. Rep.* **71** 91, 1921.

5 Cruickshank, J. N. Two Cases of Congenital Diaphragmatic Hernia, *Glasgow M. J.* **105** 81, 1926.

6 Rendich, R. A. The Radiographic Examination of the Alimentary Tract with Analysis of Routine Examinations of 5,033 Hospital Cases, *J. Radiol.* **5** 124, 1924.

7 Macmillan, A. S. Diaphragmatic Hernia, *Am. J. Roentgenol.* **7** 143, 1920.

8 Beclere, quoted by Morrison. Diaphragmatic Hernia of Fundus of Stomach through the Esophageal Hiatus, *J. A. M. A.* **84** 161 (Jan. 17) 1925.

9 Morrison, L. B. Diaphragmatic Hernia of Fundus of Stomach Through the Esophageal Hiatus, *J. A. M. A.* **84** 161 (Jan. 17) 1925.

10 Carman, R. D., and Fineman, Solomon. The Roentgenologic Diagnosis of Diaphragmatic Hernia, with a Report of Seventeen Cases, *Radiology* **3** 26, 1924.

difficulty in reducing the hernia. The bowel and omentum were tied around the opening on the under side, and I could not remove the adhesions without injuring the intestines, so I continued the incision downward, opened the peritoneal cavity and operated from below and above, cut the diaphragm out from the hernial opening toward the periphery, reduced the bowel and omentum and sewed up the enlarged opening in the diaphragm. That operation was performed first by Berard in France. His patient succumbed, undoubtedly because Berard was obliged to operate during a period of acute intestinal obstruction. Then another French surgeon, Anvray, repeated the operation on a patient with intestinal obstruction who had come to him reasonably early. He succeeded in reducing the hernia, and his patient recovered.

Dr Stone of Baltimore had a similar case, in which he made first an abdominal incision and then an incision through the wall of the chest.

The extension of the lapel incision is simple. It just crosses the diaphragm, so that one does not need to open the abdominal cavity any more than from 1 to 2 inches (2.5 to 5 cm) in order to have access to the adhesions on the under side. Dr Stone's patient recovered. His difficulty was above the diaphragm, and it seems to me that in those cases the thoracic incision gives more ready access to the diaphragm and will serve a purpose which cannot be obtained by the peritoneal route alone.

DR L. T. LEWALD. I should like to call attention to two conditions in which an operation should not be performed unless some complication has occurred. I refer particularly to complete absence of the left half of the diaphragm. Dr Harrington referred to that under his heading "partial absence." The other condition is that which occurred in a case referred to by Dr Meyer, the disease was thoracic stomach, in which there is no deficiency in the diaphragm, but the stomach is developed above the diaphragm. Dr Harrington spoke of the development of the diaphragm just at the time that the stomach was also developing, and it is now possible to conceive of the stomach as being developed above a perfectly developed diaphragm. Percival Bailey first called attention to this in the dissecting room. I have reported two cases of this sort,<sup>18</sup> and another case has been recently reported in Liverpool by Roberts.<sup>19</sup> In one of my cases the roentgenograms determined the exact position of the diaphragm in relation to the stomach and the stomach was above the intact diaphragm. An operation was performed because the child had twenty-four hour retention in the stomach because of pyloric obstruction. He was undersized, and at the age of 7 he was smaller than a boy of 4. Dr Downes performed a gastro-enterostomy.

The other problem is to determine roentgenographically whether there is need for operation in a case of complete absence of half of the diaphragm, and then to operate only on such patients as show some complication.

I should like to ask Dr Harrington if he can explain how this complete absence of half of the diaphragm occurs.

I have two patients of this type. In one case, we feel we have been able to demonstrate the fact that the diaphragm is absent completely by comparing it with a normal side view. There is no evidence of a diaphragm on the left side. In the other case intestinal contents in the chest cavity, the stomach down in the pelvis and only one leaf of the diaphragm are demonstrated.

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18 LeWald, L. T. Congenital Absence of Left Half of Diaphragm, *Arch Surg* **14** 332 (Jan) 1927.

19 Roberts, R. E. *Brit J & Radiol* **32** 11 (Jan) 1927.

portion of the diaphragm arises chiefly from the inner lumbocostal arch with only a few fibers arising from the external lumbocostal arch. There is usually a triangular space of muscular deficiency between the outer crus of the lumbar portion of the diaphragm, the last muscular part of the costal portion of the diaphragm and the twelfth rib. The apex of the triangle is curved upward and forward toward the tendinous portion of the diaphragm. The base is turned downward and somewhat backward and partly rests on the twelfth rib, but sometimes it extends in front of the body of the psoas muscle. The borders of this hiatus are muscular and are more or less of sphincter-like construction. The space is closed by a membrane which consists of two sheaths, the upper sheath comes from the pleura, and the lower sheath is thin and is a continuation of the iliac fascia. This space was first described by Bochdalek, in 1848, and has been named the foramen Bochdalek.

The central tendon of the diaphragm is reniform, with the central portion slightly curved and extending into the dome, of which the greater portion is on the right side. At the base of this right portion and entirely within the tendon is a large quadrilateral foramen which gives passage to the inferior vena cava. This opening is on a level with the disk between the eighth and ninth dorsal vertebrae.

The diaphragm receives its innervation from the phrenic (usually from the fourth and sometimes through branches from the third and fifth cervical roots), the sympathetic and the intercostal nerves which send motor and sensory fibers to its peripheral parts (fig. 1).

#### EMBRYOLOGY

The formation of the diaphragm from embryonic structures is a highly complex process, as its muscular elements are derived from several sources.

The anterior, lateral and central parts, which comprise the greater portion of the diaphragm in the adult, are formed from the transverse septum and fused ventral mesentery. The remaining, posterolateral portion is formed by the fusion of the dorsal mesentery and the mesoderm derived from the receding wolffian body and the pleuroperitoneal membrane derived from the pulmonary ridge. It is difficult to determine the exact amount of the muscle tissue that is derived from each of these structures, as there is probably considerable variation, but it is also probable that the dorsal mesentery forms the posterior and central portions containing the esophageal opening. The mesodermic cells from the receding wolffian body form the right and left crura. The pleuroperitoneal membrane grows ventrally and closes the remaining opening (hiatus pleuroperitonealis) between the peritoneal celom and pleural celom, by fusing with the transverse septum, and forms the lateral portion of the diaphragm. Failure of fusion or proper deposition of the



Fig 14—The chest before the barium meal



Fig 15—The stomach immediately after the barium meal

In the foregoing it is seen that embryonic herniation would occur most commonly in the embryo from 11 to 20 mm. Congenital herniation of somewhat later formation can be explained on many of the same grounds. It is due to the failure of parts of the diaphragm to mature or to excessive degeneration of muscle elements in the formation of the central tendon.

#### CLASSIFICATION

Numerous classifications of diaphragmatic hernia are based on embryology, etiology, pathologic anatomy, the site of the opening in the diaphragm, the presence or absence of a sac, the contents of the hernia and other conditions. It is difficult or impossible to make most of these classifications clinically, they can usually be made only after operation or at necropsy. From a clinical and surgical standpoint, the history of injury is important in determining the type of treatment to be instituted and the probable prognosis in surgical cases. Better results are usually obtained from operation in cases of traumatic origin than in the cases due to embryonic defects. For this reason I have classified all types in two main groups, nontraumatic and traumatic, and subdivided these according to the various common types as follows:

##### I Nontraumatic

- 1 Congenital, due to embryonic deficiency, of which the most common sites in probable order of frequency of occurrence are (a) through the hiatus pleuroperitonealis (foramen of Bochdalek) without an enclosing sac, (b) through the dome of the diaphragm, (c) through the esophageal opening, (d) through the foramen Morgagni and (e) through the gap left by absence of the left half of the diaphragm.
- 2 Acquired after birth through an embryonic fusion point of the diaphragm, it may occur at sites named under congenital types.

##### II Traumatic

- 1 Indirect injury to diaphragm, it may occur at any point but usually through an embryonic fusion point, the result of crushing injuries and usually with a sac.
- 2 Direct injury to the diaphragm, the hernia may occur at any point and is usually the result of penetrating wounds (gunshot or knife wound) and usually without a sac.

#### MAYO CLINIC SERIES

Since 1908 fifty-one cases of diaphragmatic hernia have been diagnosed at the Mayo Clinic, of this number twenty-four were not considered surgical. In the latter the diagnosis was made by roentgen-ray examination during the course of the general examination, and it was not thought that the hernia was producing sufficient symptoms to warrant surgical intervention at that time. Many of the patients are under treatment for other conditions and return for observation from time to time, ultimately some of them will probably come to operation. It is of

this procedure could scarcely be imagined, the heart being under my fingers. After the heart had been massaged for about half a minute, its beat improved considerably, and within a minute it had returned to about as good a condition as it had been in before the emergency occurred.

The hernial opening was an enlargement of the esophageal hiatus in a direction to the left and slightly forward. It was large enough to admit three fingers. There was no hernial sac, merely an open window leading directly into the pleura. After the stomach had been emptied of its fluid with the aid of a stomach tube, the hernial opening was closed by four silk sutures, a



Fig. 17—Large bowel after barium clyster

procedure which was rendered somewhat difficult by the fact that the anterior border of the opening was partly concealed by the liver which had to be drawn forward to permit placing the suture. After the end of the operation some fluid was removed from the trachea and bronchi through the bronchoscope by Dr. Kernan. The patient did fairly well at first, but died on the following day.

The hernial ring in this case was not a separate opening but an extension of the esophageal hiatus. The esophagus came down through it in the normal way. The cardiac end of the stomach was in the abdomen, the rest of the stomach, about four fifths of it, being turned upward, formed a sharp kink

The average duration of symptoms at the time of operation was nine and a half years, seventeen of these patients gave no evidence of injury, while ten dated the onset of their symptoms from severe injuries

### SYMPTOMS

The symptoms are dependent on the organs involved in the hernia Lacher<sup>12</sup> states that every abdominal organ except the genitalia, bladder and rectum has been found in the thorax at least once It is apparent that the symptoms will be varied and inconstant, in general they may be divided into thoracic symptoms, which are probably least noted, and abdominal symptoms, which are the most constant The thoracic symptoms are caused by encroachment on the pleural space with impairment of respiration and circulation The most common of these are dyspnea, cyanosis, palpitation of the heart and pain or sense of fulness

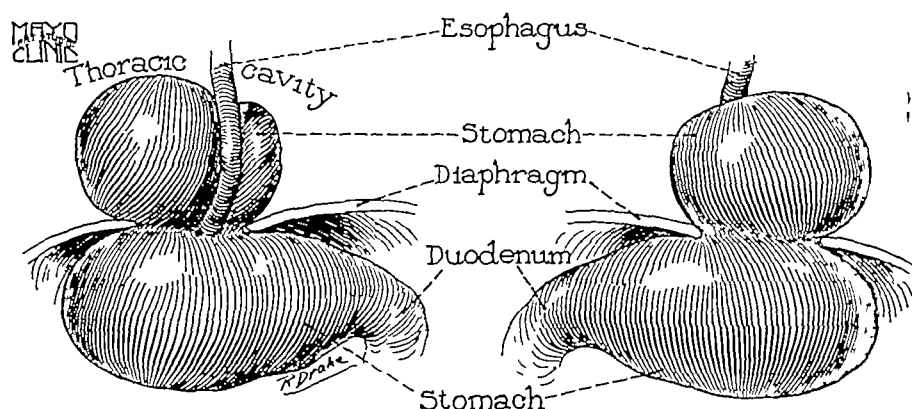


Fig 3—The portion of the herniated stomach posterior and to the right of the esophageal opening with pressure and partial obstruction to the lower portion of the esophagus is shown

in the chest These are present in varying degrees and combinations, depending on the site and degree of the encroachment on the pleural cavity, or they may not be present at all The abdominal symptoms are caused by incarceration of the abdominal viscera in the hernial opening, this causes disturbance of the function of the organs involved, varying from slight irritation to strangulation and obstruction

Morrison<sup>9</sup> states that the most constant symptom is pain just above or anterior to the ensiform cartilage The symptoms often simulate irregularly those of peptic ulcer or cholecystitis with hemorrhage, or pain radiating to back or left shoulder, gastric distress, palpitation at night and inability to lie on the back or left side without regurgitation of acid fluid He states that all but one of his forty-two cases had been

12 Lacher, quoted by Unger and Speiser Am J Roentgenol 15 135 1926



# PRELIMINARY MEDICATION IN GENERAL ANESTHESIA

WITH SPECIAL REFERENCE TO THE MARGIN OF SAFETY AND  
POSTOPERATIVE LESIONS OF THE LUNG

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AND

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The reasons for giving preliminary medication are to prevent psychic shock, to increase the margin of safety, to modify or abolish any and all untoward symptoms during induction and maintenance of anesthesia and after operation, and, most important of all, to prevent possible pathologic lesions in the lungs. Preliminary medication should be given regardless of whether the anesthesia is local, spinal, regional or general. In the search for a suitable agent for preliminary medication, magnesium sulphate should be considered. It synergizes with morphine by prolonging its effect, and if ether is used, the magnesium sulphate deepens the anesthesia.

Table 1 is a summary of cases from more than 200 similar cases selected in sequence at the Presbyterian Hospital of New York City in which 400 cc of a sterile 4 per cent chemically pure magnesium sulphate solution (4 drachms [15.5 Gm] of the salt) was given by hypodermoclysis one and a half hours before operation.<sup>1</sup> Three eighths of a grain (24 mg) of morphine in divided doses was given by hypodermic injection. When magnesium sulphate was used, the average time after operation before a sedative was required was sixteen hours. Table 2 shows a parallel series of cases in which morphine alone was given. The average time after operation that a sedative was given was four hours.

Table 3 shows a second series of cases, in sequence, from another hospital in which 6 cc of 25 per cent solution of magnesium sulphate divided into three doses, each dose containing one eighth of a grain (8 mg) of morphine sulphate, was injected intramuscularly as preliminary medication to nitrous oxide-oxygen and procaine anesthesia. The gases are used only to render the patient unconscious and to complete the analgesia. The patient remains pink, and the usual signs of third stage anesthesia are not present. Table 4 gives the results in a parallel series of cases in which morphine dissolved in water was given. The results in each hos-

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1 Gwathmey, J. T., and Greenough, James. Synergistic Analgesia with Nitrous Oxide—Oxygen and Magnesium Sulphate, *M. Rec.* **100** 583 (Oct 1) 1921.

after meals, (2) inability to take quantities of food, (3) a sense of smothering or distress and (4) inability to vomit or belch gas during an attack (figs 2 and 3)

The most constant symptom in the surgical cases at the Mayo Clinic was epigastric pain, it was noted in practically all cases. In four cases it radiated to the thorax anteriorly, in three cases to the back, and in two



Fig 5—Left diaphragmatic hernia, abdominal left rectus incision, almost the entire stomach in the left thoracic cavity, a portion of transverse colon and spleen having been removed from the cavity. Insert *a* shows hernial opening to left of esophageal opening with large cavity in the left lower thorax. Insert *b* shows closure of hernial opening with interrupted catgut reenforced with linen sutures after a phrenic neurectomy.

cases to the left shoulder. The other symptoms in order of frequency were regurgitation of sour fluid or food, vomiting, gastric distress and distention with difficulty in belching of gas at times, distress immediately after eating, hemoptysis and melena.

TABLE 3—*Patients Receiving Magnesium Sulphate and Morphine*

Number	Operation	Time of Postoperative Sedative
1	Colpoperineorrhaphy	None
2	Appendectomy and cholecystectomy	None
3	Appendectomy	12 hours
4	Appendectomy and cholecystectomy	3 hours
5	Appendectomy	10 hours
6	Perineorrhaphy	12 hours
7	Cholecystectomy	16 hours
8	Hysterectomy and double oophorectomy	9 hours
9	Secondary closure	None
10	Nephrectomy	23 hours
11	Hysterectomy	None
12	Perineorrhaphy, appendectomy, ventrosuspension	5 hours
13	Appendectomy	None
14	Appendectomy	None
15	Appendectomy and cholecystectomy	24 hours
16	Appendectomy and Cobelt's cyst	12 hours
17	Radical amputation of the breast	None
18	Appendectomy and Schroeder's operation	12 hours
19	Appendectomy	4 hours
20	Schroeder's operation	None
21	Perineorrhaphy	4 hours
22	Hysterectomy, colporrhaphy, perineorrhaphy	17 hours
23	Appendectomy and cholecystectomy	12 hours
24	Appendectomy and dilatation of cervix	None
25	Appendectomy and cholecystectomy	32 hours
26	Separation of adhesions, omental graft under liver	6 hours
27	Barrett's operation, separation of adhesions	36 hours
Total lapse of time before postoperative sedative		256 hours
Average lapse of time		15 hours

TABLE 4—*Parallel Series of Cases in Which Magnesium Sulphate Was Not Given*

Number	Operation	Time of Postoperative Sedative
1	Cholecystectomy	12 hours
2	Cholecystectomy	8 hours
3	Cholecystectomy	4 hours
4	Cholecystectomy	2 hours
5	Appendectomy	12 hours
6	Appendectomy	3 hours
7	Appendectomy	1 hour
8	Appendectomy	None
9	Appendectomy	1 hour
10	Drainage of appendix	2 hours
11	Freeing stricture	2 hours
12	Freeing stricture	1 hour
13	Gastro-enterostomy, appendectomy	3 hours
14	Freeing adhesions	12 hours
15	Repair of hernia	2 hours
16	Radical cure of hernia	None
17	Herniotomy	11 hours
18	Herniotomy	None
19	Removal of appendix, ovary, tubes and uterus	1 hour
20	Hysterectomy	12 hours
21	Hysterectomy	None
22	Hysterectomy	2 hours
23	Hysterectomy	2 hours
24	Hysterectomy	3 hours
25	Hysterectomy	7 hours
26	Cesarean section	4 hours
27	Cesarean section	3 hours
Total lapse of time before postoperative sedative		110 hours
Average lapse of time		4 hours plus



Fig 7—Traumatic diaphragmatic hernia following gunshot wound The bullet is seen in the left flank at the level of the eleventh rib The entire stomach was below the diaphragm after operation

safer agent Acetylene has passed the experimental stage, having been used in thousands of cases in Germany<sup>6</sup> Propylene is still in the experimental stage and should not be used clinically at this time The best results with these agents are obtained by using nitrous oxide and ethylene in combination, nitrous oxide and oxygen should be used at first and ethylene should be added when unconsciousness ensues The anesthetic is then continued with nitrous oxide, oxygen and ethylene

In regard to immediate safety for life, ether has a wider margin than any of the gases described Its use is increased in value by premedication more than any other general anesthetic, as the following experiments show<sup>7</sup>

#### REPORT OF EXPERIMENTS

*Without Preliminary Medication*—On June 15, 1915, at 10 30 a m, a dog weighing 13 Kg was given 0.5 cc of 2 per cent morphine solution At 11 34, intravenous administration of ether was started At 11 38½, complete anes-

TABLE 5—*Comparison of Analgesic and Anesthetic Doses of Propylene, Acetylene, Ethylene and Nitrous Oxide, With and Without Preliminary Medication*

Cases	Results Obtained			
	With Preliminary Medication		Without Preliminary Medication	
	Complete Analgesia, Percentage of Anesthetic Gas	Anesthesia, Percentage of Anesthetic Gas	Complete Analgesia, Percentage of Anesthetic Gas	Anesthesia, Percentage of Anesthetic Gas
Propylene-oxygen	28	50	50	50
Propylene air	36	46	46	46
Acetylene-oxygen	41	41	75	75
Ethylene-oxygen	73	92	87	94
Nitrous oxygen	91	93	93	93

thesia was obtained by the use of 134 cc of ether solution At 11 42, respiratory failure occurred, only 99 cc more of the ether solution was required

The animal was then resuscitated by artificial respiration A period varying from four to seven days or more was allowed for recovery After this rest, the experiment was repeated as follows

*With Preliminary Medication*—On Sept 7, 1915, at 2 50 p m, 0.5 cc of 2 per cent morphine solution was given At 3 10, 6.05 cc of paraldehyde and 13 Gm of potassium bromide were given At 3 59, intravenous administration of ether was started At 4 01½, complete anesthesia was obtained, using 87 cc of ether solution At 4 09½, respiratory failure occurred, 245 cc more ether solution was required

In both experiments the dog received sufficient morphine to make him easy to handle, so this factor can be excluded from the final result Without pre-

6 Gwathmey, J T Ethylene and Preliminary Medication, Arch Surg 10 568 (Jan) 1925

7 Gwathmey, J T Anesthesia Reviewed, New York M J 104 825 (Oct 28) 1916, 104 895 (Nov 4) 1916

of the herniated abdominal viscera, operation is usually indicated. In acute cases due to penetrating wounds with rupture of a viscus, immediate operation is demanded. In acute cases due to indirect injury of the diaphragm without injury to the viscera, palliative measures are probably preferable until the shock of injury and the acute symptoms subside. Gastric lavage is often of great assistance in relieving the acute gastric symptoms. Placing the patient in Fowler's position often relieves the respiratory embarrassment. Stimson<sup>15</sup> stated that induction of artificial pneumothorax before operation may reduce the shock and

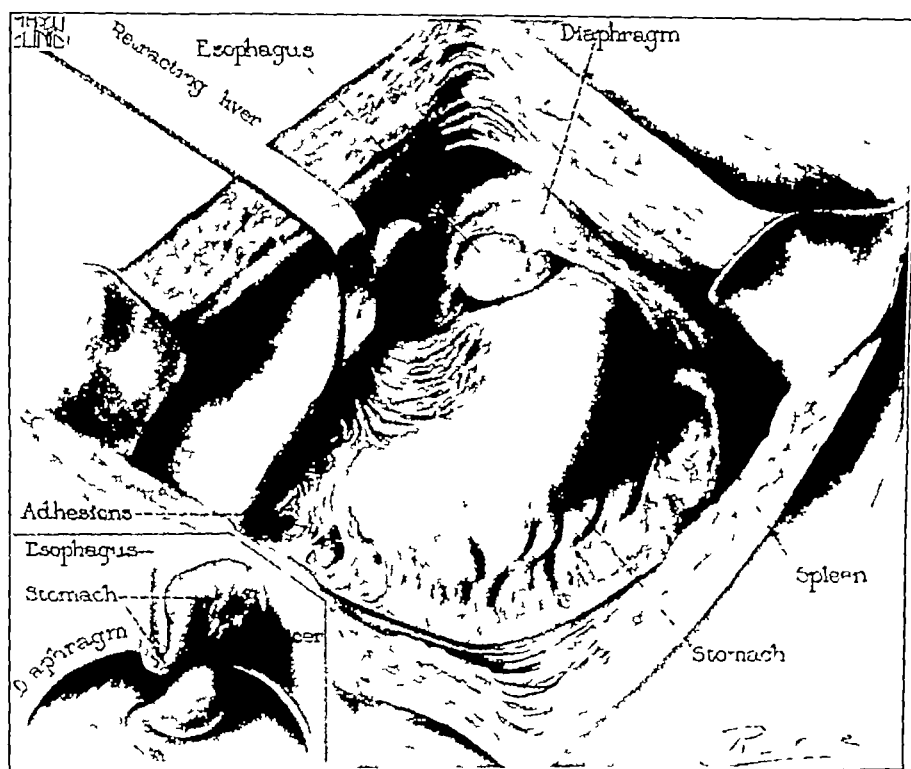


Fig 9—High right rectus incision, one third of the stomach herniating through esophageal opening of diaphragm. Many adhesions of the pyloric end of the stomach to under surface of the liver, due to a previous operation on the gall-bladder. The insert shows a diagrammatic sketch of the portion of the stomach above the diaphragm, containing ulcer.

aid in the reduction of the hernia. The patient should be so placed on the operating table that the abdominal viscera gravitate toward the pelvis. I prefer a semi-upright position with the head and thorax tilted well back.

The method of approach may be thoracic or abdominal or a combination of the two. In the twenty-seven surgical cases, all three methods

<sup>15</sup> Stimson, P. M. Congenital Diaphragmatic Hernia of the Right Side its Diagnosis in life, *Arch. Pediat.* 40: 647, 1923.

The albino rats employed were obtained from one source and were kept on a constant, well balanced diet for at least two weeks before the tests were made. After fasting for from sixteen to twenty hours immediately before the experiments, they were weighed and the preliminary medication injected, the dosage being computed on the basis of kilograms of body weight. Water was supplied during the fasting period.

Four animals were employed for each experiment. Two were given intramuscular injections of 0.8 cc of magnesium sulphate solution (50 per cent) per kilogram of body weight with procaine hydrochloride (2.5 per cent) and morphine sulphate ( $\frac{1}{8}$  grain in 2 cc). Ten minutes after the preliminary injections, all four animals were placed in the gas chamber and were given the same mixture with the gages set, so that all were killed within thirty minutes. The controls jumped around and struggled against the anesthetic. The animals receiving the preliminary medication fell asleep without going through a stage of excitement. After the animals were killed with the anesthetic mixtures, necropsy was immediately performed. Lesions in the lungs occurred in the ones that did not receive preliminary medication, gross examination showed distention, edema and congestion. After ether was used, it was not unusual to find atelectasis involving one or more of the lobes. The lungs of the animals that received preliminary medication were relatively normal. Illustrations of this condition are given in Nelson's Loose Leaf Surgery.<sup>9</sup>

#### CONCLUSIONS

The preliminary medication suggested for clinical purposes is an injection of morphine sulphate, one-eighth grain dissolved in 2 cc of magnesium sulphate solution (50 per cent). This is to be repeated once or twice at twenty or thirty minute intervals, according to the age, weight and general condition of the patient. If an idiosyncrasy is present, it will develop before the time for the third dose. One fourth of a grain of morphine is usually sufficient for women.

If the patient is to be put to sleep entirely, we give, in addition to the hypodermic injections, a small dose of ether,  $2\frac{1}{2}$  ounces (14.2 cc), by rectum, paraldehyde, 2 drachms (7.8 Gm) and olive oil, sufficient to make 4 ounces (118.4 cc). Any nurse can give this retention enema, and the procedure does not require an anesthetist, as surgical anesthesia would never be induced by this medication. If nitrous oxide and oxygen are used, the oxygen should be increased to 30 or 50 per cent, instead of the usual 9 or 10 per cent. If procaine hydrochloride is used for the skin and the peritoneum, the same percentage is required as would be used if preliminary medication had not been given. If chloroform and ether are used, only a few drops are required.

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<sup>9</sup> Nelson's Loose Leaf Surgery, vol. 9, opposite p. 514

Of the five nontraumatic cases, the hernial opening was at the esophageal opening in four, in one it was anterolateral with congenital absence of a portion of the diaphragm (patent hiatus pleuroperitonealis). Of the three traumatic cases, two were due to crushing injuries, and the hernia in both cases was at the esophageal opening. In one case, the injury was due to a gunshot wound with the opening in the dome of the diaphragm (figs 4, 5, 6 and 7).

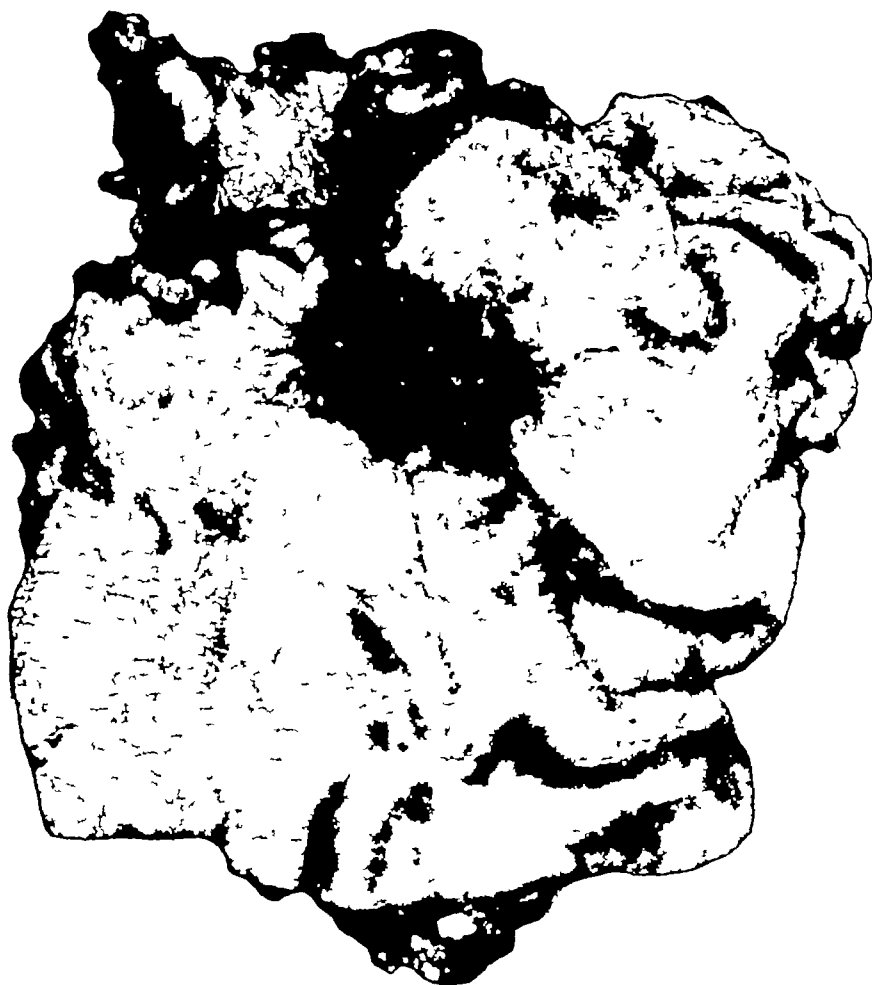


Fig 11—Resected portion of the stomach, with large perforating gastric ulcer high on the lesser curvature, measuring 3 by 25 by 2 cm

The operation was performed through the abdomen in all cases, and in one case I performed phrenic neurectomy through a cervical incision at the time of closure of the hernia, because the large size of the opening and the contraction of the diaphragm made closure difficult, the hernial opening was then easily closed. I believe that this procedure is applicable in extreme cases, it prevents herniation of the abdominal viscera by producing eventration of the repaired diaphragm.



sibility of its employment in the prevention of postoperative pneumonia in abdominal operations. In the Cincinnati General Hospital, a great many operations for acute abdominal conditions were performed. Two groups of operations in which this preliminary medication would seem applicable are perforated ulcer and gunshot wounds of the abdomen. In both, postoperative pulmonary complications are too frequent. Preliminary medication is a method of preventing these complications to a certain degree, in the least ideal cases in which operations have to be performed.

As I interpret it, the production of postoperative or postanesthetic pulmonary lesions depends on the quantity of the anesthetic used. That, I understand, is the same in both instances. I wonder what the effect of the preliminary medication and operation under local anesthesia would be on the lungs. In all probability, pulmonary complications might not occur, but since postoperative complications do take place after local anesthesia, I wonder whether preliminary medication would have any effect.

DR CHARLES D. LOCKWOOD. I am sure that all surgeons performing a great many thoracic operations have been impressed with the importance of this paper. Six years ago, I began performing thoracoplasties, and I was impressed with the necessity of doing them under local anesthesia. Dr. Willy Meyer's paper impressed this fact on me, and I performed a large number of thoracoplasties under local anesthesia through connection with two large tuberculosis sanatoriums. I performed this operation on twenty-five people. I performed more than that, but they were all done under local anesthesia, and I thought that I succeeded well. The operations were successful, and I was able to make resections in all of these cases under local anesthesia.

In my connection with another institution, I was almost forced to use general anesthesia. At first I used nitrous oxide and then ethylene, and since using them, my operations have been more successful. My patients recover better, and I am beginning to think that I shall use general anesthesia in all my cases. The startling results with general anesthesia combined with magnesium sulphate as demonstrated by Dr. Gwathmey seem to justify the use of gas or ethylene anesthesia in the future in thoracoplasty. My work has been treating patients with tuberculosis, although I have had two or three with abscesses of the lung and two or three with bronchiectasis. I shall continue to use general anesthesia, especially ethylene, because I have had the best results with that combined with magnesium sulphate.

DR GWATHMEY. During the World War, I was anesthetist for Major Jack Yates, M.C., in France. According to a plan previously worked out in the laboratory, each patient that came to the table received  $\frac{3}{8}$  grain of morphine in divided doses,  $\frac{1}{8}$  grain at a time. Strictly speaking, these patients were never anesthetized but were merely kept unconscious with nitrous oxide and oxygen, from 40 to 75 per cent. Analgesia was always thoroughly established. Certain reflexes, such as that of the lid, were active, but the muscles were relaxed. Probably 80 per cent of these patients needed thoracic or abdominal operations.

During this time we did not have a scare or a death that could in any way be ascribed to the preliminary medication or the anesthetic, this shows that the procedure was unquestionably safer than the use of nitrous oxide alone. Dr. Walter Lathrop, surgeon of the State Hospital, Hazelton, Pa., states that all of his patients receive  $\frac{1}{8}$  grain (0.010 Gm.) of morphine in 2 cc. of a 50 per cent solution of magnesium sulphate, in divided doses,

of this additional risk, treatment can be postponed and the patient informed that the symptoms will probably not be completely relieved. The hernial opening can usually be well exposed through an incision along the costal margin or, if a vertical incision is made, by making a transverse incision as well. At times there is difficulty in reducing the herniated viscera because of the suction exerted by the negative pressure of the thorax. This difficulty is usually overcome by C. H. Mayo's method of inserting a tube through the hernial opening into the thorax.

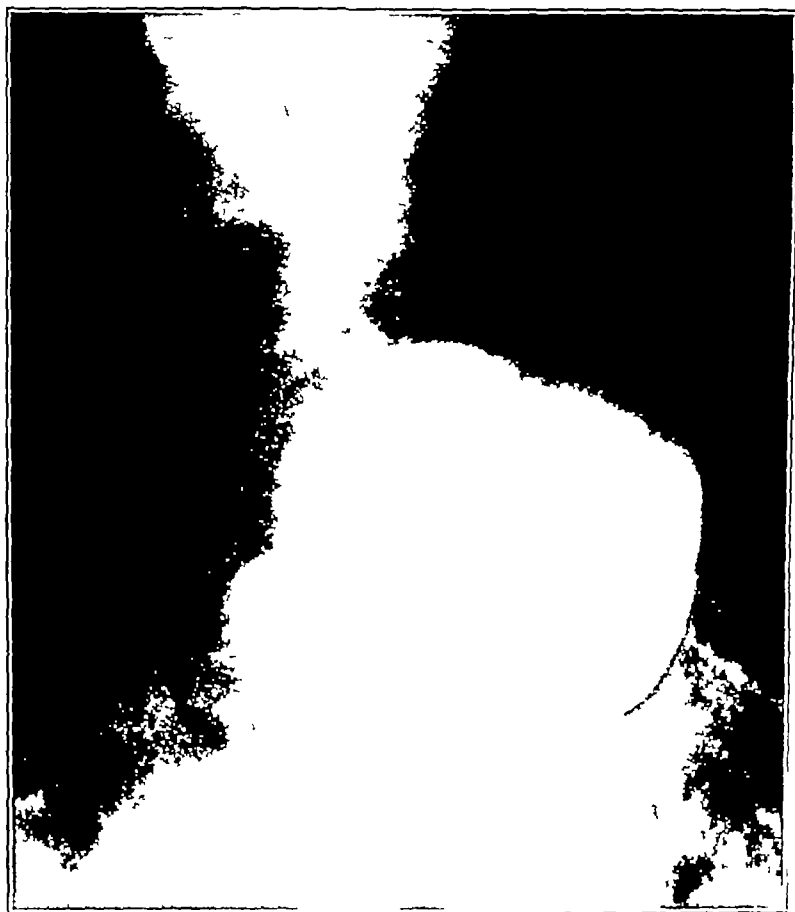


Fig. 13—Seven months after resection of stomach and repair of diaphragmatic hernia. A small part of the remaining stomach was in good position below the diaphragm with the anastomosis free.

and thus permitting air to enter the pleural cavity in order to reduce the negative pressure and facilitate reduction of the hernia. A similar result may be obtained by inducing preliminary artificial pneumothorax, as was done in two cases. Whenever pneumothorax is produced surgically, the lung should be reexpanded at the completion of the operation.

If there is any serious difficulty in exposing and repairing the hernial opening through the abdomen the thorax may then be opened as in the

# PERSISTENT NONTUBERCULOUS PNEUMOTHORAX

REPORT OF TWO CASES ONE OF TEN YEAR'S DURATION, THE  
OTHER OF MORE THAN ONE YEAR'S DURATION

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It has been recognized for a number of years that there is a form of nontuberculous spontaneous pneumothorax<sup>1</sup> It is generally believed that these patients make a prompt recovery with complete expansion of the collapsed lung within a few weeks Such, however, is not always the case, so that it appears desirable to report two cases in which expansion of the lung did not occur in the usual manner In one case the collapse persisted for slightly more than a year, and in another case the lung has *failed to expand after eleven years*, and apparently the collapse is permanent

## REPORT OF CASES

CASE 1—M V, a woman, aged 77, first noticed acute symptoms on Nov 8, 1916, following an attack of bronchitis *Roentgen-ray examination showed spontaneous localized pneumothorax* involving the upper two thirds of the right side of the chest Roentgenograms were made at intervals over a period of *seven years, and the condition did not show any change during that time*

For about four years the patient disappeared from observation A few months ago, she returned to me complaining of some distress in the left side of the chest Roentgen-ray examination was made, and the right lung was found to be collapsed as formerly observed It is now fully eleven years since the diagnosis of pneumothorax was made, and the right lung has not shown any apparent expansion of the upper and middle lobes during that time

*Roentgen-ray examination* revealed complete absence of lung markings on the right side of the chest as far down as about the fifth rib anteriorly and the eighth rib posteriorly The appearance was typical of pneumothorax The opposite lung was free from any evidence of pulmonary tuberculosis The lower portion of the right side of the chest showed lung markings and a mottled appearance indicating the presence of lung tissue, which, however, was not fully aerated, indicating a partial atelectatic tendency There was a paradoxical movement of the diaphragm on respiration On inspiration the diaphragm on the left side descended in a normal manner, but it ascended on the right side The uncollapsed lung on the right side acted in a similar manner, that is, on inspiration the upper border was elevated so that the vertical dimension was 6 cm, whereas on expiration it was only 3.5 cm, this showed that there was definite expansion of this portion of the lung during

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<sup>1</sup> LeWald, L T Bilateral and Unilateral Nontuberculous Spontaneous Pneumothorax, Arch Surg **12** 440 (Jan) 1926

bined operation if necessary. Closure of the hernial opening is essential to the relief of symptoms, suturing herniated viscera to the abdominal wall or the hernial opening is palliative. Paralysis of the diaphragm by phrenic neurectomy is helpful in closing the large hernial openings when considerable tissue has been lost.

The operative risk is not great, there was no mortality in the eight cases reported. The best surgical results are attained in the traumatic cases, in all three cases in this group relief of symptoms was complete. Results of operation through an abdominal incision are satisfactory, there was one recurrence in eight cases.

#### ABSTRACT OF DISCUSSION

DR WILLY MEYER, New York. Dr Harrington's presentation of this subject covers the ground completely. Regarding diagnosis, I should like to call attention to the method used by Dr LeWald in his roentgen-ray work ten years ago. It was to my mind, the egg of Columbus, and it should be employed if possible in every case. His patient was a child. After having administered the bismuth by mouth, Dr LeWald lifted him, holding his head down. Naturally the greater portion of the bismuth meal had to run above the diaphragm, and the most brilliant result of roentgenography was obtained. An operation was performed by Downs by way of the abdomen with the help of gastro-enterostomy. The child recovered.

I should like to say something with reference to a personal observation. I reported a case before this Association in 1922. The patient had been referred to me by the pediatrician. The case was that of a child a few weeks old. At first glance, the diagnosis made was acute pneumonia, roentgen-ray analysis, however, showed that there was a seemingly complicated diaphragmatic hernia. The patient had high fever and there was tenderness over the abdomen. The child had vomited for a number of days, but the vomiting had stopped for the last forty-eight hours before I saw him, there had not been any bowel movement or passage of gas. Operation seemed to be the only procedure. Naturally, the question arose as to how to proceed. Because there was also considerable complication in the thoracic cavity, so far as the lungs were concerned, I decided to start with the abdominal incision. When the abdomen had been opened, pus was oozing out in large amounts. Local conditions were confusing. We saw a portion of the small intestine and of the transverse and descending colon, with the sigmoid. We searched carefully, but did not find the diaphragmatic opening. At that moment, whether rightly or wrongly, I decided to progress downward from the pylorus, to see what I could find. I let the intestines pass through my hands as gently as possible, when the infant suddenly vomited a large amount of intestinal contents and died with symptoms of fecal drowning.

Even though the infant had not vomited for the last forty-eight hours (and I mentioned that in 1922 at our Washington meeting), the stomach should have been washed first. I was glad to hear from Dr Harrington that in all of his cases in which the patients were operated on for diaphragmatic hernia the stomach was washed first. A surgeon should not omit this precaution.

As the parents were present in the hospital, we were able to obtain permission for an inspection of the wound. We pulled the various parts aside behind the liver, 1 inch (2.5 cm) to the side of the upper lobe of the kidney.

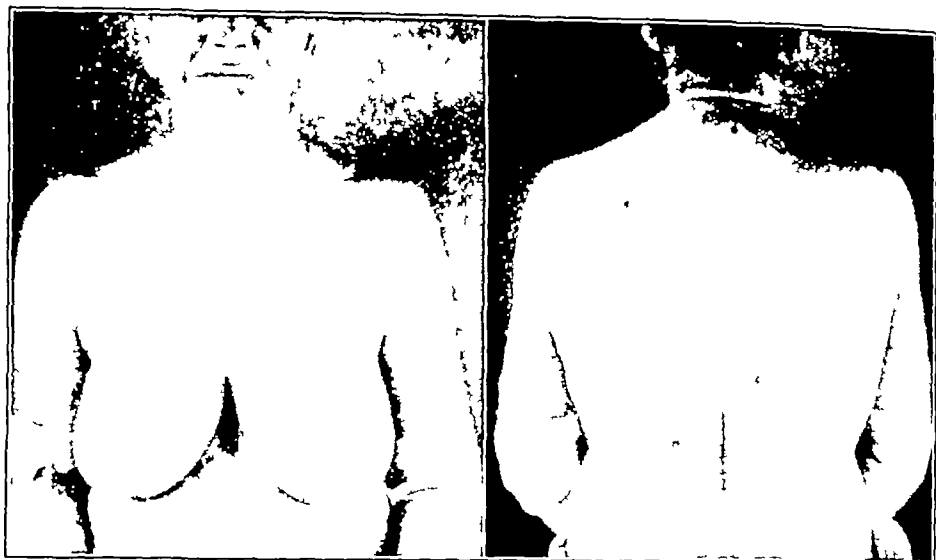


Fig 2 (case 1) —Persistent pneumothorax of ten years' duration, right side, the perfect symmetry of the chest should be noted. If the greater portion of the right lung were congenitally absent, it is remarkable that the chest wall shows no deformity, it is therefore believed that the condition is due to spontaneous nontuberculous pneumothorax.



Fig 3 (case 2) —Persistent pneumothorax of one year's duration. Figure X shows the complete absence of lung markings, left side (A) due to spontaneous nontuberculous pneumothorax, heart and mediastinum displaced to right (B). Figure Y complete expansion did not occur until one year later (A), slight pleuritic adhesions about the diaphragm, heart and mediastinum returned to normal position (B).

Dr Harrington showed that the small intestine was involved in ten and the large intestine in twelve out of thirty-five cases. Usually the large intestine accompanies the small intestine, so that we place the associated involvement of the large intestine in the thorax at a higher figure.

When the small intestine and the large intestine pass through the aperture in the diaphragm, the seat of the obstruction is almost invariably in the colon, because there the contents of the intestine are somewhat semisolid or solid, and they greatly add to the tendency to earlier constriction in the colon when both the colon and the intestine are in the thoracic cage. A picture of acute intestinal obstruction is then presented and the mortality in operations for acute intestinal obstruction in hernia of the diaphragm is usually above 50 per cent. In most cases of acute intestinal obstruction, such as from umbilical hernia, the hernia is closed at the time of the operation and without much loss of time, but without such technical difficulties as are associated with operations on the diaphragm. The procedure undertaken to close the opening in the diaphragm often results in death.

I had occasion to operate and reoperate on a child who had a recurrent diaphragmatic hernia. The indication for the operation in each instance was intestinal obstruction. I decided that I would reduce the danger of the operation by performing an appendicostomy, since the obstruction was in all probability in the colon, as had been demonstrated at the first operation. This was done, thereby a safety valve was established, because the appendix is proximal to the point of obstruction. If the appendix is absent, the cecum can be used instead. That is all that is necessary in the average case of acute intestinal obstruction resulting from diaphragmatic hernia. At a later date the operation for repair can be performed. Using the appendix has more than one point of advantage. I believe that in some of these cases recurrence is due to tension in the abdomen against the line of suture in the diaphragm. If there is an opening on the proximal side of the seat of obstruction the gas will escape through the opening to the outside. Thus, the diaphragm is not raised by the distended contents of the abdomen and healing will take place under much better circumstances. I feel as Dr Meyer does, that in the majority of these cases it is more satisfactory to operate by making a thoracotomy incision. Then one can make a lapel incision and work with two hands within the thoracic cavity. Occasionally it is impossible to deal with all the adhesions just beneath the diaphragm through the thoracotomy incision.

A child, aged 6, was admitted to the Brockton Hospital three years ago for acute intestinal obstruction. Dr Samuel Goddard operated on her and found that the obstruction was due to a diaphragmatic hernia that involved the transverse colon. He reduced it, but the opening in the diaphragm was inaccessible, and he closed the abdomen. Later the child was admitted to the same hospital, in Dr Goddard's service, for the same condition. Again he performed laparotomy, this time for the purpose of closing the opening in the diaphragm, but it was inaccessible, and he was unable to close it. He sent this patient to our clinic for treatment. After preliminary roentgen-ray studies had been made which demonstrated the obstruction in the transverse colon I performed an appendicostomy. The child was thus prepared for the operation of repair. I decided to do it by the peritoneal route, making an incision along the costal border. I felt morally sure that I would be able to close the hernia, but it was physically impossible for me to close the opening in the diaphragm. Two weeks later, I made a transthoracic approach not removing the ribs but making the lapel incision with all the layers of the thoracic wall. After cutting away the adhesions and the loop of the colon I had dis-

the so-called sedimentation test, which is always positive in active tuberculosis and negative in cases of nontuberculous pneumothorax. The test has been accepted in Europe but as yet is not well known in this country. It has proved to be of greatest value in clinical observations in Denver.

DR LEWALD I should have mentioned particularly the possibility of *congenital absence of part of the lung*. I never had seen such a case, but we have discussed that at times as one of the possibilities in this case. I could not understand how there would be such a well developed chest and wondered whether in Dr Hedblom's case the conformation of the chest was preserved with the absence of the lung and whether he would consider this case as one of possible absence of the lung.

DR HEDBLOM There was no asymmetry of the thorax, but marked dyspnea was present, as one would expect from the positive thoracic tension on one side.

DR LEWALD Roentgenograms had not been taken of this woman until she came to me eleven years ago, which shows the advisability of a roentgen-ray examination early in life of the chest of every person.

DR GRAHAM Dr Lihenthal asked me to say a few words for him, namely, that he wished to call attention to the fact that lipomas causing pressure effects might be regarded as malignant tumors, and that he therefore, wished to emphasize the importance and advisability of exploratory operation on any tumor of the mediastinum that is causing a severe pressure effect, because it might be a removable lipoma. He, however, did not have any cases of this kind to report. Obviously he does not refer to infiltrating or metastasizing growth.

The other point that he wanted brought out is that there was a difference in the roentgen-ray picture of lipomas and transplanted fat. This was an observation with which I was not familiar. He calls attention to the fact that transplanted fat appears light, and almost transparent. This was clearly shown in a case of apicolysis with a fat transplant of great size. A number of lipomas reported in the literature were fairly opaque to the roentgen rays. In our own case, the roentgenogram did not show anything.

DR TOREK I wish to report a case of diaphragmatic hernia. The patient, a boy, aged 4, was admitted to the pediatric department of the hospital on Jan 5, 1926. He had been well six weeks prior to admission when he began to complain of cramps after a full meal. He was nauseated, but did not vomit. His appetite was poor, he was constipated, and he lost some weight.

Physical examination showed that the heart was displaced to the right, and a gurgling râle was heard. It was also believed that there was an exudate in the left side of the chest, therefore a roentgen-ray examination was made (fig 14). This showed, besides the displaced heart, what seemed to be air bubbles in the left pleural cavity, as well as some lines suggestive of contractions of the bowel. Exudate was not present. A barium meal was then given (fig 15), which showed that the stomach and part of the small intestine were in the left pleural cavity. The stomach and bowel, however, emptied in normal time (fig 16), and as the patient did not complain an operation was not considered.

On January 26, a barium clysma was given, and the roentgenogram (fig 17) showed the transverse colon to be in the thorax, while the cecum, ascending colon and sigmoid were in the abdomen.

During the night of January 29, the child began to complain of abdominal pain localized in the midline, paroxysmal in character, lasting about two or three minutes, with intervals of ten minutes. The abdomen was tympanic, and stiffening of the intestine was seen in the upper left quadrant.

I was consulted on January 30 and found the patient in collapse and vomiting at every attempt to drink. The hernia had evidently become strangulated.

Operation was immediately performed. The abdomen was opened through a median epimesogastric incision. When the region of the diaphragm was exposed, the mesentery of the small intestine was seen stretched in a direction upward and through the diaphragm. No part of the small intestine was in the abdomen, nor any part of the large intestine above the descending colon. Only a small cardiac portion of the stomach was in the abdominal cavity, the rest was in the thorax.

Comparing these observations with the roentgenograms taken when the child was in good condition, it is evident that the same thing happened which not infrequently occurs in ordinary hernias: the expulsion of an additional amount of abdominal contents through the hernial opening had caused strangulation.



healthy-looking, and none of them has developed tuberculosis during the years that have elapsed since the collapse. We find that ten cases of bilateral pneumothorax have been reported. In the issue of the *American Review of Tuberculosis* for November, 1925, Briggs reviewed eight cases and reported one, LeWald reported another case in the issue for January, 1926. Four of these patients were definitely tuberculous, one had had asthma, one did not show any other condition at autopsy, one was probably tuberculous, two were nontuberculous, but autopsy was refused, and one had had bilateral empyema.

The following three cases are reported because there are certain rather unique and interesting features. In case 1, the patient had spontaneous collapse of first one and then of the other lung over a period of five years, in case 2, the patient had two collapses eight months apart, and the one in case 3 had fourteen collapses on the two sides and at one time experienced a bilateral collapse. In none of these cases was there evidence of organic pathologic change in the lungs. In a fourth case, the lung of the patient, who is still under treatment, has collapsed twice, but there is definite evidence of an early pulmonary tuberculous lesion.

#### REPORT OF CASES

CASE 1—Dr. W., aged 32, an orthopedic surgeon, had a family history which was not significant. He did not know of ever having been exposed to tuberculosis. The patient had had a chronic cough from the time he was 4 years of age until he was 12. He had had chronically diseased tonsils and frequent attacks of acute tonsillitis from the age of 4 until he was 22. Attacks of croup occurred during the sixth year. He had had typhoid at the age of 12, followed by a good recovery. At the age of 16, he began to tire easily, and while at military school, one year later, he noticed that he lacked the endurance of other boys, although he had no definite symptoms of disease. When he entered medical college at the age of 18, he felt well. During his second year, tuberculosis was suspected, but he continued to work, and soon felt normal and remained so while he was in college and during thirteen months of internship in a large hospital. He then worked with an orthopedic surgeon for five months, and during this time had a return of the old symptoms: malaise, lack of endurance and other symptoms. He then joined the navy and remained in this service for ten months. He was given a roentgen-ray examination, but evidence of pulmonary tuberculosis was not found.

He then began an internship in the Kings County Hospital, N. Y. Two months later, he had a spontaneous collapse on the left side. He stayed in bed for twenty-four hours. Pain and shock gradually subsided, and he returned to work. The second attack occurred two months later, when he was "run down," although his health was better than when he was 16 years of age. The third attack took place three months later, in New York City, while he was carrying a heavy suitcase, and was accompanied by moderate shock. After he had begun general practice, he had several more attacks, first on one side and then on the other, which resulted from fatigue or from unusual lifting. During 1923 and 1924, his condition was below par, and he had tendovaginitis of the left achilles tendon. In January, 1924, he had another

The colon was easily drawn down, beginning with the transverse colon and the attached omentum and ending with the cecum and appendix. The small intestine came down in like manner until its upper portion was reached, which would not give way. Traction on the small intestine was therefore stopped, and attempts were made to deliver the stomach, beginning at the cardiac end. This was difficult. For a time it appeared that it would be necessary to perform a thoracotomy to assist in its delivery, but the abdominal manipulations finally succeeded in bringing down an enormously distended stomach, almost completely filled with fluid. Even if the patient had been an adult, instead



Fig 16—The small bowel three and a half hours after the barium meal

of a child of 4 years, the stomach would have been considered a very large one. When about two thirds of the stomach had been delivered, the remainder came down with a rush, and the moment it was completely down a serious collapse began. The patient stopped breathing, and the heart became excessively slow and faint, continuing to become slower and fainter, like that of a dying person. I had my fingers in the opening leading to the thorax so that the heart and aorta could be distinctly felt. Believing that the patient had aspirated some fluid regurgitated from the stomach I at once placed the patient in a pronounced Trendelenburg posture, and some fluid ran out. As the heart would necessarily cease beating within a few seconds, the indication to massage it was evident and more favorable circumstances for practicing

was noted. On April 4, 1925, eight months later, there again occurred a complete collapse of the left lung. After reexpansion (fig 2), Dr Vass could not find any definite pulmonary pathologic change. In June, 1925, the patient was referred to Dr J Garnett Nelson, of McGuire Clinic, Richmond, Va. Dr Nelson advised sanatorium treatment, believing the collapse to be due to a possible pulmonary tuberculosis. The patient was then referred to Dr Woods Price, at Saranac, who also reported, in September, that results of the physical and roentgen-ray observations were negative. The patient was therefore refused admission to the Trudeau sanatorium. He could not find any focal infection which might account for the collapse. Dr Price wrote: "It is conceivable that he may have had a small area of tuberculosis close to the pleura, which could not be demonstrated either by x-ray or physical



Fig 2 (case 2) —Complete reexpansion of the lung. There was no evidence of tuberculosis or other pulmonary pathologic changes.

examination, yet it may have been tuberculosis and have caused the condition." This patient is in perfect health and has been working since leaving Saranac. He has not had a recurrence of the condition.

CASE 3—R. H. G., aged 22, a traveling salesman, was referred to us on July 7, 1926, by Dr W. R. Whitman of Lewis-Gale Hospital, Roanoke, Va., with a diagnosis of spontaneous pneumothorax, probably tuberculous. His complaints were marked pain in the right shoulder, a feeling of constriction in the right side of the chest and dyspnea. The family history was not significant. To his knowledge, the patient had never been exposed to tuberculosis. He had been a strong, husky child, and, with the exception of the usual diseases of childhood, he had never been sick until he had had influenza four years previously, from which he had made a good recovery. He had never

This case furnishes a good illustration of how the condition of a patient who has had only mild symptoms from diaphragmatic hernia may become practically hopeless through the occurrence of strangulation, even if gangrene does not result. It furthermore, emphasizes the advisability of operating on these patients before serious symptoms arise, in other words, as soon as the diagnosis of a true diaphragmatic hernia has been made. In this particular case there would surely not have been any difficulty in securing a favorable outcome if the patient had been operated on while his condition was still good.

to relieve the pleura of the tension due to negative pressure and thus to facilitate the healing of the opening in the visceral pleura. On August 9, the left lung showed a partial collapse involving the apex of the lung, the base being well expanded. At this time, we aspirated 800 cc from the right side and made a roentgen-ray examination (fig 4). The patient was kept at absolute rest in bed, but on September 5, and again on October 15, the right lung collapsed, the last time apparently as a result of gently turning in bed. It seemed that the opening in the pleura must be increasing in size, since the attacks were becoming more frequent in spite of absolute quiet. Dr W B Porter, professor of medicine at the Medical College of Virginia, suggested putting 300 cc of the patient's blood in the right pleural cavity. We did this, and

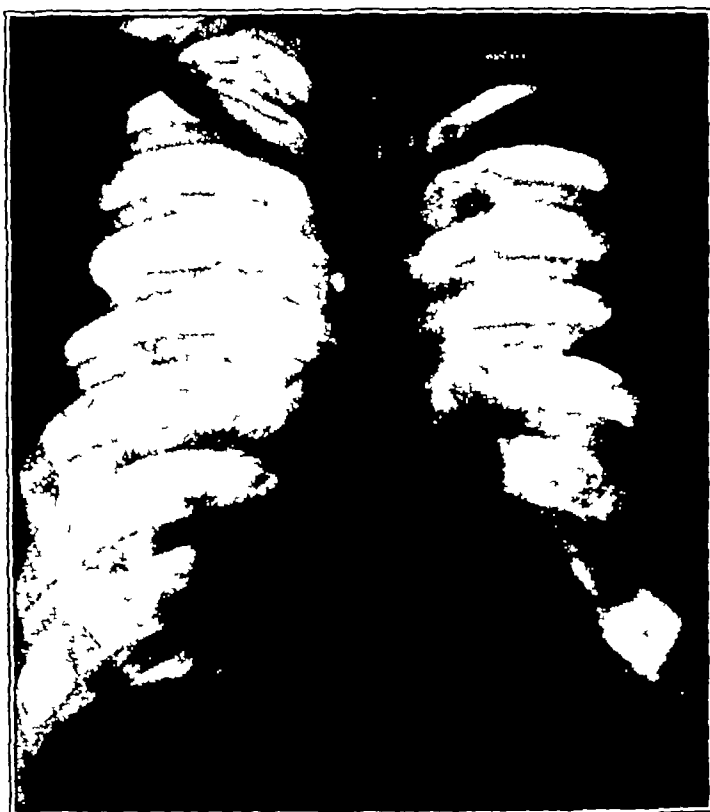


Fig 4 (case 3)—Partial collapse of both lungs, 800 cc of air was withdrawn from the right side before the roentgenograms were taken

for thirty-six hours placed the patient in various positions which would allow the blood to reach the entire surface of his visceral pleura, hoping that it would clot and organize when it came in contact with the pulmonary tissue within the sinus, and that in some vague way it might react on the pleurae to produce adhesions when the lung reexpanded. From that time until his discharge on Jan 15, 1927, he had no further trouble, and on discharge was taking considerable exercise in the form of walking. Since that time, he has had three complete collapses of his left lung (fig 5). This total collapse of the left lung surprised us, as we had felt that adhesions must have prevented a complete bilateral collapse when the left lung went down at the apex during the time that we were keeping the lung at zero pressure. He was referred to Dr Lemon at Rochester, who wrote that he could not find any evidence

pital were the same. The patients were comfortable for from fifteen to sixteen hours after operation, without becoming nauseated, vomiting or having pain in the wound and with normal respiration, pulse and temperature during and after operation. After using this technic in a

TABLE 1—*Patients Receiving Magnesium Sulphate and Morphine\**

Number	Operation	Time of Postoperative Sedative
1	Direct hernia	None
2	Double inguinal hernia	32 hours
3	Carcinoma of rectum	29 hours
4	Carcinoma of rectum	28 hours
5	Acute appendicitis, general peritonitis	30 hours
6	Incarcerated hernia	24 hours
7	Chronic appendicitis	17 hours
8	Acute appendicitis	13 hours
9	Carcinoma of stomach	13 hours
10	Ischio-rectal abscess	12 hours
11	Chronic appendicitis	12 hours
12	Chronic appendicitis	12 hours
13	Chronic appendicitis	10 hours
14	Chronic appendicitis	5 hours
15	Inguinal hernia	4 hours
16	Lacerated wound of leg	3 hours
Total lapse of time		244 hours
Average time		16 hr 16 min

\* Gwathmey, J. T., and Hooper, C. W. Newer Methods of Preliminary Medication. Proc. Inter-State Post Graduate Medical Assembly of North America, 88:94 (Oct. 12) 1925.

TABLE 2—*Parallel Series of Cases in Which Morphine and Water Alone Were Given*

Number	Operation	Time of Postoperative Sedative
1	Ischio-rectal abscess	None
2	Carcinoma of rectum	None
3	Hernia	15 hours
4	Incarcerated hernia	10 hours
5	Chronic appendicitis	2 hours
6	Acute appendicitis	2 hours
7	Chronic appendicitis	6 hours
8	Double hernia	14 hours
9	Left inguinal hernia	1 hour
10	Chronic appendicitis	2 hours
11	Carcinoma of rectum	2 hours
12	Chronic appendicitis	11 hours
13	Carcinoma of stomach	1 hour
14	Acute appendicitis	1 hour
Total lapse of time		49½ hours
Average time		4 hr 6 min

number of cases, Smythe<sup>2</sup> made the remarkable discovery that 6 cc. of 25 per cent magnesium sulphate solution injected into the muscle in three divided doses is equivalent to the 16 Gm. (4 drachms) of the salt heretofore used.

2 Smythe, F. D. Further Experiences with Synergistic Analgesia. Tennessee M. A. 15:97 (June) 1922, Synergistic Analgesia and Its Surgical Anesthesia supp. 37:85 (July) 1923.

strangling the patient prevented this Dr A H Hoge, of Bluefield, W Va, has since offered a suggestion worthy of trial. He would wait for a few days following a collapse and then introduce a needle and ascertain by manometric readings whether the pleural opening is closed. If it is, he would inject the irritant. The idea of keeping the pleural pressure at or as near zero as possible for some months, thus relieving the visceral pleura of its negative tension and thereby promoting the healing of pleural lesions, would seem rational.

We believe that the injection of the patient's blood into the pleural cavity is worth trial, as it is a simple measure, devoid of pain and general reaction. While one case does not prove anything it would seem probable that this may have had something to do with preventing a recurrence in case 3, thereby meriting further trial.

Mt Regis Sanatorium

### DISCUSSION

DR WILLY MEYER, New York From what I have read in the foreign literature the patients have received injections of nitrate of silver solution in such cases, 0.5 per cent, by which sufficient irritation of the pleura was produced in a few instances so that the opening in the pulmonary pleura closed spontaneously.

DR LOCKWOOD, Pasadena, Calif I have had no such cases, although I had a number of cases of spontaneous pneumothorax. Why could not the lung be inflated and sutured and perhaps the opening located? That just occurred to me as a possibility.

DR FELIX BAUM, Newark, N J I notice in the roentgenograms shown by Dr Watson that in none of them is a formation of fluid visible. In such cases, the patients should not be treated surgically. The best thing to do is to let them alone.

A mechanical or surgical treatment is indicated only in the presence of symptoms of continuous infection of the pleural sac which constantly causes the formation of fluid.

DR EVARTS A GRAHAM I agree with what has been said.

An ordinary dose of morphine (from  $\frac{1}{8}$  to  $\frac{1}{4}$  grain [8 to 16 mg]) makes any general anesthesia safer, but does not completely remove psychic impulses. With morphine alone, a rise in the systolic blood pressure, ordinarily from 10 to 40 mm and occasionally up to 80 and 90 mm, is noted just prior to the administration of the anesthetic.<sup>3</sup>

The statistics from the Presbyterian Hospital and those of Smythe prove beyond all question that, compared with water, the use of magnesium sulphate with morphine prolongs the effect of morphine three or four times. Experiments on animals have shown that the usual clinical dose of 2 cc of 50 per cent magnesium sulphate solution administered intramuscularly is at least one hundred times removed from the fatal dose.<sup>4</sup> It is safe and has been administered more than 20,000 times at the Lying-In Hospital in more than 7,000 cases, each patient receiving three injections with and without morphine.<sup>5</sup>

Magnesium sulphate should be injected intramuscularly to avoid local complications. A long needle is used and is held at right angle to the skin instead of at the usual acute angle. As the needle is withdrawn, the magnesium sulphate is injected into the muscle, the subcutaneous tissue and skin being avoided entirely.

As will be seen from table 5, the margin of safety with all general anesthetics is greatly increased when asphyxial and cyanotic symptoms are eliminated. The oxygen can be increased from 2 to 34 per cent in obtaining analgesia when preliminary medication has been employed. Analgesia must be obtained when surgical operations are performed, anesthesia may or may not be necessary.

Table 5 shows that only 2 per cent of difference exists between complete analgesia and anesthesia with nitrous oxide and oxygen, a smaller percentage than exists with the other gases. This indicates that nitrous oxide is the most dangerous of the gaseous anesthetics as regards immediate safety to life. Both laboratory and clinical experience prove this statement. In comparison with other agents, nitrous oxide may be called an asphyxiating anesthetic. It is almost impossible to secure anesthesia in the majority of patients with nitrous oxide and oxygen without causing cyanosis and asphyxiation to a greater or less extent when preliminary medication is not used. By comparison, ethylene is a much

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3 Coburn, R. C. Blood Pressure in Operative Surgery and General Anesthesia, *J. A. M. A.* **82** 1748 (May 31) 1924.

4 Gwathmey, I. T., and Hooper, C. W. Synergistic Analgesia and Anesthesia with Special Reference to Magnesium Sulphate, Ether, Morphine and Novocaine, *J. Lab. & Clin. Med.* **10** 641 (May) 1925.

5 Davis, A. B. Amelioration of Labor Pains by Morphine-Magnesium Sulphate Injections and Colonic Instillations, *Surg. Gynec. Obst.* **40** 868 (June) 1925. Harrar, I. A. Rectal Ether Analgesia in Labor, *Am. J. Obst. & Gynec.* **13** 486 (April) 1927.



Dr Stuart W Harrington, Rochester, Minn "Diaphragmatic Hernia"

During the interval between the morning and afternoon sessions the association lunched as guests of the president, Dr Franz Torek

The meeting was resumed in the New York Academy of Medicine at 2 p m, the association going into executive session for the transaction of necessary business, the adoption of a new constitution and by-laws, election of new members and election of officers for the ensuing year

On resumption of the scientific session the following papers were presented

Dr Evarts A Graham, St Louis "Lipomas of the Mediastinum"

Dr Willy Meyer, New York "Thoracic Surgery in America—A Retrospect and an Outlook"

Dr Leon T LeWald, New York "Persistent Nontuberculous Pneumothorax, Report of a Case of Over Ten Years and One of Two Years' Duration"

Dr Everett E Watson, Salem, Va "Recurring Spontaneous Pneumothorax"

#### WEDNESDAY, MAY 11

The scientific program being completed, operative clinics and dry clinics were held in various hospitals by the members of the association



liminary medication, 134 cc of ether solution was used to secure complete anesthesia as against 87 cc with preliminary medication. Respiratory failure required the use of only 99 cc of ether when preliminary medication was not employed as against 254 cc of ether with preliminary medication, showing that the animal which had received preliminary medication was in a better condition than one which had not.

This experiment was verified by the following test:

*Margin of Safety of Ether Anesthesia With and Without Preliminary Medication*—Four albino rats were employed. Two were given intramuscular injections of 0.8 cc of magnesium sulphate solution (50 per cent) per kilogram of body weight with procaine hydrochloride (2.5 per cent) and morphine ( $\frac{1}{8}$  grain in 2 cc). Two other animals served as controls and were not given any preliminary medication. Ten minutes after the preliminary injections, all four animals were placed in the same gas chamber and were given the same ether vapor (34 per cent). The animals used as controls jumped around and struggled against the anesthetic and died within from eight to ten minutes. The synergized animals were anesthetized quickly and quietly and survived the ether from twenty to twenty-five minutes. This experiment was repeated several times with the same results.

The foregoing experiments with animals, as well as clinical experience, prove that

- 1 Anesthesia occurs sooner and less ether solution is used after the administration of preliminary medication.

- 2 The margin of safety between complete anesthesia and respiratory failure is lengthened when preliminary medication is employed, which makes the giving of an anesthetic a safer procedure, in other words "the margin of safety" is increased.

In order to find out why animals that received preliminary medication show an increased tolerance for ether, necropsies were performed on several of them. As a result of our observations, we determined to try all the general anesthetics.

#### RESULTS OF EXPERIMENTS WITH ALL GENERAL ANESTHETICS

Our experiments showed that regardless of the anesthetic employed—ether, nitrous oxide-oxygen or one of the hydrocarbon gases (acetylene, ethylene or propylene) lesions in the lungs occur when animals are not given preliminary medication. These results represent a year's work in which approximately 500 animals were employed to determine the value of preliminary medication in general anesthesia. Laboratory data show what clinical experience verifies—that proper preliminary medication is of equal importance with the general anesthetic agent.

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8 Gwathmey, I. T. and Hooper, C. W. Newer Methods of Preliminary Medication, Proc. Inter-State Post Graduate Medical Assembly of North America 88-94 (Oct. 12) 1925.

- 2 They may in no wise change the Constitution or By-Laws
- 3 They may neither elect new members nor alter the status of existing members, other than to apply the provisions of Article IV—Sec 2
- 4 They may not deplete the principal of the Endowment Fund

SEC 2—Officers and Councilors shall be elected at the annual meeting of the Association, and shall take office on the first day of January, next succeeding The President and the Vice President shall be elected for a one year term of office and neither may be reelected to succeed himself in the same office The Secretary and the Treasurer shall be elected for a one year term of office and either or both may be reelected indefinitely The outgoing President shall automatically become a Councilor for a one year term of office The other four Councilors shall be elected, one each year, for a four year term of office, but no Councilor may be reelected to succeed himself

SEC 3—Vacancies occurring among the officers and councilors during the year shall be temporarily filled by action of the Council, subject to approval of the Association at the next regularly convened meeting

#### ARTICLE VI—COMMITTEES

SEC 1—At the opening session of the annual meeting there shall be elected, after nomination from the floor of the Association, a Nominating Committee of three This Committee shall prepare a slate of nominees for officers and councilors and shall present their report at the executive session of the Association

SEC 2—The Council is empowered to appoint a Membership Committee, an Auditing Committee, a Committee on Program and Transactions, a Necrology Committee and such other committees as may in its opinion be necessary All such committees shall render their report at the executive session of the Association

#### ARTICLE VII—FINANCES

SEC 1—The fiscal year of the Association shall coincide with the calendar year The books of the Association shall be kept and audited on this basis

SEC 2—Members shall contribute to the financial maintenance of the Association through the medium of initiation fees, annual dues and special assessments The amount of the annual dues and the initiation fees shall be determined by the By-Laws

Special assessments may be charged against individual members, as determined by the By-Laws, when material submitted for publication in the annual transactions of the Association exceeds such limits as may be set in the By-Laws If, at the end of any fiscal year there be a deficit in the current funds of the Association, the Council may send out notices to that effect and invite Active Members to contribute the necessary amount so that no deficit be carried over from one fiscal year to another The Association may, in any regularly convened meeting, vote a special assessment for any purpose whatever, and such special assessment shall become an obligatory charge against the classes of members affected thereby

SEC 3—To meet the current expenses of the Association, there shall be available all revenue derived from annual dues, special assessments, and income from Endowment Fund, subject to the provisions of Section 4 following Funds derived from the payment of initiation fees shall not be available for current expenses

SEC 4—All funds derived from the payment of initiation fees shall be placed in a special fund, to be invested and reinvested in legal securities, and to

It is well known that anesthesia has been produced in thousands of patients without the use of preliminary medication and without fatal results, but these experiments possibly may help to explain some deaths resulting from pneumonia and other pathologic conditions of the lungs that have hitherto been assigned to other causes<sup>10</sup>

1 Sufficient facts are herewith presented to warrant the routine elimination of psychic shock, which is always present and which is greatly increased by strapping a patient who is conscious and apprehensive and anesthetizing him without any preliminary medication. This results in hyperpnea followed by apnea, especially when ether is used, with the possibility of resultant pulmonary lesions.

2 By rendering a patient unconscious or nearly so in his own bed the stage of excitement is eliminated, anesthesia is induced and maintained with a minimum amount of the agent, and the patient is assured the greatest possible postoperative comfort.

#### ABSTRACT OF DISCUSSION

DR KERNAN: I use anesthesia in operations on both the tonsils and the adenoids. I have to consider the effect of preliminary anesthesia on that operation as I have always favored preliminary anesthesia. I like complete anesthesia in operations on the tonsils and adenoids because it is a great annoyance to have the cough and swallowing reflex present. I have always had some qualms of conscience about it, because others favor the presence of the cough reflex for the sake of protecting the lungs.

It has always seemed to me that quiet was needed after the operation. I always thought that a great deal of vomiting and coughing after the operation tended to bring on hemorrhage by the movements of the throat and even could dislodge an embolus and cause an abscess of the lungs. Others have maintained that it was necessary to have the patient regain consciousness as quickly as possible in order that the reflexes might return.

Dr Gwathmey has given just the combination needed. The preliminary medication makes possible deep anesthesia with a minimum amount of ether or whatever is used, and Dr Archibald has eliminated the possibility of cough. He has demonstrated that the cough not only is not needed to protect the lungs, but also that it is a danger to the lungs. Myerson in Arrowsmith's clinic in Brooklyn, after performing bronchoscopy after tonsillectomy, has found that in more than 50 per cent of 200 such cases blood was found in the trachea and bronchi. He also found that, in the case of coughing, the less deep the anesthesia the deeper blood was found in the trachea and bronchi. His condition was in contrast to other cases in which the anesthesia was deep, and in which it was possible to use the suction and sponge to the larynx.

Dr Gwathmey has quieted all the qualms of conscience I ever had about employing preliminary anesthesia.

DR WILLIAM ANDRUS: One point about preliminary medication that I think is not so applicable to thoracic surgery but which impresses me as being

<sup>10</sup> Wilson, S. R. Ether Convulsions. *Lancet* 1:1117 (May 2) 1927.  
Gwathmey, I. T. Ether Convulsions. *Lancet* 1:139 (June 23) 1927.

SEC 2—The Senior Councilor, as of the year of meeting of the Congress, shall be certified to the Congress of American Physicians and Surgeons, as the delegate of this Association to the Executive Committee of the Congress. The Councilor next in seniority shall be certified as the alternate.

SEC 3—The Secretary is empowered to certify any member of the Association resident in the District of Columbia, in Maryland or in Virginia as a member of the Committee on Arrangements of the Congress.

SEC 4—The Treasurer is authorized to pay upon demand any assessment levied by the Executive Committee of the Congress against this Association.

#### ARTICLE IV

SEC 1—New Members may be elected only at an annual meeting of this Association. A three-fourths vote of those present and voting shall be required to elect. Candidates shall be presented in groups in the following order: Candidates for Honorary Membership, retirement of Active Members to Senior Membership, Associate Members eligible to Active Membership, candidates for Active Membership, candidates for Associate Membership.

SEC 2—Active Membership shall be limited to 100. The candidate, to be eligible, must be resident in the United States or Canada, must be a graduate in medicine of not less than ten years' standing, and must have made a meritorious contribution to knowledge pertaining to the thoracic field.

SEC 3—Associate Membership shall be limited to fifty. The candidate, to be eligible, must be resident in the United States or Canada, and must be a graduate in medicine of not less than five years' standing. Associate Members shall be permitted five years in which to qualify for Active Membership, under provisions of Article IV, Sec 2, of the Constitution.

SEC 4—The number of Senior Members shall be unlimited. The candidate, to be eligible, must have been an Active Member of this Association for not less than ten years, or, having been an Active Member, have passed the age of sixty, or become incapacitated by illness.

SEC 5—Honorary Members shall be limited to twenty-five. The candidate, to be eligible, may be a citizen of any country, does not necessarily have to hold a degree in medicine, but must have made an exceptional contribution to knowledge pertaining to the thoracic field.

SEC 6—Any candidate for membership in this Association who has failed of election for three years shall be automatically dropped from the list of candidates and his name may not be again proposed until after a lapse of five years.

SEC 7—The Council may recommend that any member whose dues are in arrears for two years, or who has been absent, without sufficient excuse, from four consecutive annual meetings, shall have his membership withdrawn.

#### ARTICLE V

SEC 1—The President of the Association shall perform all duties customarily pertaining to the office of President. He shall not only preside at all meetings of the Association, but also at all meetings of the Council. The President shall be elected from the Active Members of the Association.

SEC 2—The Vice President of the Association shall perform all duties customarily pertaining to the office of the Vice President, not only as to the Association, but also as to the Council. The Vice President shall be elected from the Active Members of the Association.

repeated twice at thirty minute intervals, each patient thus receiving 1. gram (0.032 Gm) of morphine in 6 cc of magnesium sulphate. In certain cases from 1 to 1½ ounces (30 to 45 cc) of ether in oil was given per rectum (This amount of ether per rectum would not by itself anesthetize a 4 year old child.) Dr. Lathrop states that this medication, with sometimes a local agent for the skin and the peritoneum, is amply sufficient for him to carry on all surgical operations. Previous to employing such medication he had used rectal anesthesia in almost 2,000 cases without any bad effects. The advantage of the latter method is that he can converse with and secure the cooperation of the patient when necessary, which is important under certain conditions.

The series of cases of Yates and Lathrop are mentioned merely to show that it is not unusual or radical to have a patient unconscious or nearly so when brought to the operating room.

The trend of anesthetics is to get the patient on a safer basis. This can be done in part by producing analgesia and unconsciousness when desired but not necessarily surgical anesthesia.

of office Not more than two members of this Committee may be reappointed to succeed themselves The Council may, if it so desires, appoint one of its own members to serve as chairman of the Committee The duties of the Necrology Committee shall be to prepare suitable resolutions and memorials on the death of any member of the Association

## ARTICLE VII

SEC 1—Honorary members of the Association are exempt from all initiation fees, dues and assessments

SEC 2—Annual dues for Active Members shall be \$15

SEC 3—Annual dues for Associate Members shall be \$5

SEC 4—Annual dues for Senior Members shall be \$3

SEC 5—Initiation fee for those elected directly to active membership shall be \$15

SEC 6—Initiation fee for those elected to Associate Membership shall be \$5 If and when an Associate Member is elected to Active Membership he shall pay an additional \$10 initiation fee to Active Membership

SEC 7—In illustrating the annual transactions the Association will incur expenses not to exceed \$15 per article If the cost for illustrating any article exceeds the sum of \$15 the excess shall be charged as a special assessment against the member concerned

SEC 8—Income from the Endowment Fund shall be expended as the Council directs

## ARTICLE VIII

SEC 1—When the Association convenes for its annual meeting it shall immediately go into executive session but the business at this session shall be limited to

- 1 Election of Nominating Committee
- 2 Appointment of necessary committees
- 3 Miscellaneous business of an urgent nature

SEC 2—The annual executive session of the Association shall be held at the opening of the afternoon session of the second day of the meeting The order of business shall be

- 1 Reading of the minutes of the preceding meetings of the Association and Council
- 2 Report of the Treasurer for the last fiscal year
- 3 Report of the Auditing Committee
- 4 Report of the Treasurer for the current year to date
- 5 Report of the Necrology Committee
- 6 Report of the Program Committee
- 7 Action on amendments to the Constitution and By-Laws
- 8 Action on recommendations emanating from the Council
- 9 Unfinished Business
- 10 New Business
- 11 Report of the Membership Committee
- 12 Election of new members
- 13 Report of the Nominating Committee
- 14 Election of officers

respiration in spite of the fact that the diaphragm remained almost stationary or was slightly elevated during inspiration. The heart particularly the base and the aorta were displaced to the left. On inspiration, the aorta was 3.5 cm and on expiration it was 4 cm to the left of the midline (figs 1 and 2).

CASE 2—J. B., a man, aged 40, first noticed shortness of breath while walking down the street about 2 p. m. one day early in March 1926. The patient had been well up to that time. He became dizzy and consulted his physician, who requested him to return on the third day and again on the sixth day, and then referred him to Bellevue Hospital Medical College for examination. After several physicians had seen him he was referred for



Fig. 1 (case 1)—Persistent pneumothorax of over ten years duration. Figure A taken during expiration, absence of lung markings (D) over upper three fourths of right side indicating pneumothorax and absence of lung tissue collapsed lung tissue (D) upper and middle lobes poorly aerated in parts (C) lower lobe heart and trachea displaced to left. Figure B taken during inspiration, expansion of lung tissue (C) no change in area of pneumothorax (D) and collapsed lung (D). There has been no change in the appearance of this chest during ten years of personal observation. No evidence of tuberculosis.

roentgen-ray examination which showed the presence of partial collapse on the left side, the left lung being about two thirds collapsed. The patient was in Bellevue Hospital for eight weeks and later in the Long Island City hospital for about the same length of time but subsequent roentgen-ray examination showed the lung to be collapsed as at first. He complained of palpitation of the heart.



# LIST OF MEMBERS OF THE AMERICAN ASSOCIATION FOR THORACIC SURGERY

## Honorary Members

Dr Edward R Baldwin	6 Church St , Saranac Lake, N Y
Dr Alexis Carrel	Rockefeller Institute, New York
Dr Norman B Carson	7006 Maryland Avenue, St Louis
Dr Georges Dehelly	25 Rue Henry Genestal, Le Havre, France
Dr Alfred Meyer	Apt 16 E, 1225 Park Avenue, New York
Dr S Adolphus Knopf	16 West Ninety-Fifth Street, New York

## Active Members

Dr John Alexander	Surgical Clinic, University Hospital, Ann Arbor, Mich
Dr Carroll W Allen	509 Macheuca Building, New Orleans
Dr Duff S Allen	Washington University Medical School, St Louis
Dr William DeWitt Andrus	Cincinnati General Hospital, Cincinnati
Dr Edward W Archibald	52 Westmount Boulevard, Montreal
Dr Hugh Auchincloss	Presbyterian Hospital, New York
Dr A T Bazin	Montreal General Hospital, Montreal
Dr Emil G Beck	2551 North Clark Street, Chicago
Dr Ralph B Bettman	104 South Michigan Avenue, Chicago
Dr Howard L Beye	University of Iowa, Iowa City, Iowa
Dr Frank K Boland	436 Peachtree Street, Atlanta, Ga
Dr Lawrason Brown	104 Main Street, Saranac Lake, N Y
Dr Harold Brunn	350 Post Street, San Francisco
Dr Ethan F Butler	Robert Packer Hospital, Sayre, Pa
Dr J Roddick Byers	74 Westmount Boulevard, Montreal
Dr A H W Caulfield	160 Bloor Street, W Toronto
Dr Rufus Cole	960 Park Avenue, New York
Dr Samuel J Crowe	Johns Hopkins Hospital, Baltimore
Dr Elliott Carr Cutler	Lakeside Hospital, Cleveland
Dr T C Davison	Suite 35, Doctors' Building, Atlanta, Ga
Dr Victor P Diederich	Hot Springs, Ark
Captain Chauncey E Dovell, M C, U S Army	Fort Monroe, Va
Dr Kennon Dunham	1020 Union Central Building, Cincinnati
Dr Edmond M Eberts	219 Peel Street, Montreal
Dr Carl Eggers	850 Park Avenue, New York
Dr Max Einhorn	20 East Sixty-Third Street, New York
Dr Leo Eloesser	738 Butler Building, San Francisco
Dr Charles A Elsberg	64 East Fifty-Eighth Street, New York
Dr R G Ferguson	Saskatchewan Sanatorium, Fort Qu'Appelle, Saskatchewan
Dr Herman Fischer	35 East Eighty-Fourth Street, New York
Dr John B Flick	1608 Spruce Street, Philadelphia
Dr Conrad Georg, Jr	117 East Liberty Street, Ann Arbor, Mich
Dr Evarts A Graham	Washington University Medical School, St Louis
Dr Nathan W Green	152 West Fifty-Seventh Street, New York
Dr Fraser B Gurd	115 Stanley Street, Montreal
Dr James T Gwathmey	40 East Forty-First Street, New York
Dr Stuart W Harrington	Mayo Clinic, Rochester, Minn
Dr Carl A Hedblom	25 East Washington Street, Chicago

There was no history of tuberculosis in the family, and the patient was no subject to colds.

*Roentgen-ray examination* nine months after the first observation showed the left lung to be about two-thirds collapsed as previously observed. The heart and mediastinal shadows were displaced toward the right side so that the right border of the heart extended about 7 cm. from the midsternal line. At no time was there any evidence of tuberculous infiltration in the lungs. At about the level of the sixth rib the outer border of the partially collapsed lung was about 4 cm. from the costal margin. In the upper portion the lung was 8 cm. from the apex of the chest and about on a level with the second rib anteriorly. The lower lobe of the left lung was almost completely collapsed, being 12 cm. from the costal margin. *This condition persisted for one year, when the lung began to expand.* Roentgenograms made a few days ago, a year and a month after the appearance of the first symptoms show complete expansion of the left lung. The patient is now free from palpitation.

### CONCLUSIONS

1 There may be delay in the expansion of the lung in a case of spontaneous nontuberculous pneumothorax followed by recovery and expansion of the lung *after a period of one year.*

2 Permanent collapse of at least a portion of one lung may be encountered.

3 Spontaneous pneumothorax may be present for a period of years *without the development of any evidence of tuberculosis.*

### ABSTRACT OF DISCUSSION

DR HEDBLOM, Chicago: I have had one case of what appeared to be a spontaneous tension pneumothorax that proved to be a congenital absence of one lung with leakage of air from the region of the hilum. The patient was a child, aged 6, whose only symptom was dyspnea on exertion.

The physical and roentgen-ray observations were those of pneumothorax. When a needle was inserted air under pressure rushed out. A liter manometer determination showed between 20 and 30 cm. of positive water pressure. Air was aspirated repeatedly at intervals of a few days until the intrapleural pressure was atmospheric, but positive pressure persistently redeveloped. I then performed an exploratory thoracotomy and found the right pleural cavity empty without a vestige of the lung at the hilum. Air bubbled through and poured into the cavity from the region of the hilum.

I have found twenty-eight cases of congenital absence of the lung recorded in the literature, all postmortem observations. The case reported by Dr LeWald seems to be the first one definitely diagnosed during life.

I would like to ask Dr LeWald if he measured the intrapleural pressure in his case.

DR FRANK BAUM, Newark, N. J.: It is a well known fact that many of the patients with nontuberculous spontaneous or heterotaxial pneumothorax are over 40 years of age. In this particular case the cause of the pneumothorax might have been a rupture of a bleb.

As far as the differential diagnosis between tuberculous and nontuberculous pneumothorax is concerned I wish to mention that in the case of

Dr Wyman Whittemore	199 Beacon Street, Boston
Dr Abraham O Wilensky	1200 Madison Avenue, New York
Dr Sidney Yankauer	121 East Sixtieth Street, New York
Dr John L Yates	141 Wisconsin Street, Milwaukee
Dr J H Wilms	12 West Seventh Street, Cincinnati

## Associate Members

Dr David H Ballou	107 Crescent Street, Montreal
Dr Frank B Berry	168 East Seventy-First Street, New York
Dr Edward D Churchill	240 Longwood Avenue, Boston
Dr Dean B Cole	Professional Building, Richmond, Va
Dr Dan Collier Elkin	24 Doctors' Building, Atlanta, Ga
Dr James Greenough	Mary Imogene Bassett Hospital, Cooperstown, N Y
Dr Frank S Johns	Johnston-Willis Hospital, Richmond, Va
Dr Alton Ochsner	University of Wisconsin, Madison, Wis

## Senior Members

Dr William Branower	945 West End Avenue, New York
Dr Armistead Crump	20 West Fiftieth Street, New York
Dr John A Hartwell	27 East Sixty-Third Street, New York
Dr Chevalier Jackson	128 South Tenth Street, Philadelphia
Dr Howard A Lothrop	101 Beacon Street, Boston
Dr Morris Manges	72 East Seventy-Ninth Street, New York
Dr Charles L Scudder	144 Commonwealth Avenue, Boston
Dr William H Stewart	222 West Seventy-Ninth Street, New York

# RECURRENT SPONTANEOUS PNEUMOTHORAX

## REPORT OF THREE CASES

EVERETT E. WATSON, M.D.

AND

CHURCHILL ROBERTSON, M.D.

SALEM, VA.

Spontaneous pneumothorax is encountered by internists with such frequency that scarcely any interest is elicited, this is particularly true of those working among tuberculous patients exclusively. It is estimated that in from 2 to 4 per cent of all cases of tuberculosis there is a spontaneous collapse at some time. If we include the small partial pneumothoraces, which improved diagnostic acumen and particularly the more accurate roentgen-ray technic and interpretation have revealed the percentage would probably be greater than that already mentioned. Within the last three weeks, we have encountered three cases all of which resulted from pulmonary tuberculosis, in one the condition was in the minimal stage, while in the other two, it was chronic and far advanced.

An effort will not be made to discuss the pathogenesis, prognosis or treatment of these patients, as these subjects are covered in the many excellent case reports found in the medical literature. We have had a few cases of special interest which might be mentioned. Two patients in whom the contralateral lung was not badly diseased showed improvement when the pneumothorax was maintained. We recall a case in which the patient died following a complete spontaneous collapse several months after we had failed to produce a therapeutic pneumothorax; in that case we believed that our failure was due to dense adhesions. Two spontaneous collapses have occurred in our cases during the course of therapeutic pneumothorax, one following the first and the other following the second deflation.

The type which has been of peculiar interest to us is the so-called idiopathic spontaneous pneumothorax. Bruch reported 918 cases of spontaneous pneumothorax, of these 715 were proved to be tuberculous and there were only four cases to which no cause could be ascribed. A hasty review of the literature shows that more than 200 idiopathic spontaneous collapses have been reported and this can be only a small percentage of those that have occurred. Besides the three reported in this article, we have seen three other cases of complete spontaneous collapse in which neither physical nor roentgen rays examination revealed any pulmonary pathologic change after expansion. In two of these pleural tuberculosis was made in each case, the patient's recovery

there were 1,558,318 industrial accidents reported from forty-three states, of which 11,388 were fatal. Each year the totals fluctuated, being less during 1921 and 1922, then rising slowly till in 1926 the total was 1,698,494 with 10,537 fatalities. In 1926, the New York department of labor<sup>2</sup> reported 76,216 compensable disabilities of which 3,997 were injuries to the head, with 300 deaths (7.5 per cent). Males outnumbered females 14 to 1. These figures doubtless are accurate, for they have been reported by the various state industrial commissions, however, a certain number of accidents are not reported. At the present time, accidents in civil life are not being reported to any one bureau, so that figures for the total number of accidents are not available. As there is no uniformity of the data being given, they are without much real value to us. The National Safety Council<sup>3</sup> is rendering an invaluable service in studying present conditions of accident hazards all over the nation and planning methods of improvement. Although they are not yet able to give total figures with definite accuracy, they have compiled some estimates, based on known reliable data, which are of interest. During 1926, there were about 23,000 deaths from automobile accidents (probably from 600,000 to 700,000 total) in the United States, 24,000 deaths from the industrial accidents (probably a total of about 3,500,000 accidents) and 43,000 fatalities from all other accidents. This makes a total of about 90,000 deaths from accidental causes in 1926.

The National Safety Council reported that at present the death certificates of the health departments, which should be accurate and complete, are lacking in details, and often are almost worthless. The medical profession should take the responsibility of making possible a comprehensive system of reporting all accidents, accurately and uniformly, so that the data can be available by localities or states and according to traumatic agencies and other etiologic factors. From the data available, we can be fairly certain that there is a definitely rising rate of accidents each year and a corresponding increase in deaths from injuries of the head. The percentage of such injuries is roughly from 7 to 20 per cent.

#### ETIOLOGY

The table on traumatic agents (table 1) shows the distribution of our cases according to the agent, age and sex. The results are similar to those in other series. The automobile was responsible for 54.2 per cent of the injuries, which is considerably higher than in any other series in which the agent was mentioned. This fact may have a significant bearing on traffic problems in our city, and suggests that the point

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<sup>2</sup> Bull 146, New York Dept of Labor, July, 1926

<sup>3</sup> National Safety Council, Dept of Public Safety Division. Personal communications with C. E. Robb and George Opp, safety engineer.

attack on the right side accompanied by severe shock. For several days he could lie only on the affected side. A roentgen-ray examination was made at the Massachusetts General Hospital in which he was an intern, and the right lung showed complete collapse. He returned to duty at the end of three weeks. Four weeks later, he lifted a patient and had a collapse of the left lung. This diagnosis was confirmed by the roentgen ray. After three weeks, he again returned to duty. In July, 1924, he had another attack on the right side and in 1925, the left lung again collapsed. Since that time he had had no further trouble in spite of the fact that he was a busy surgeon. There were no symptoms of any kind except an occasional feeling of oppression at the base of the lungs. The results of a physical examination at this

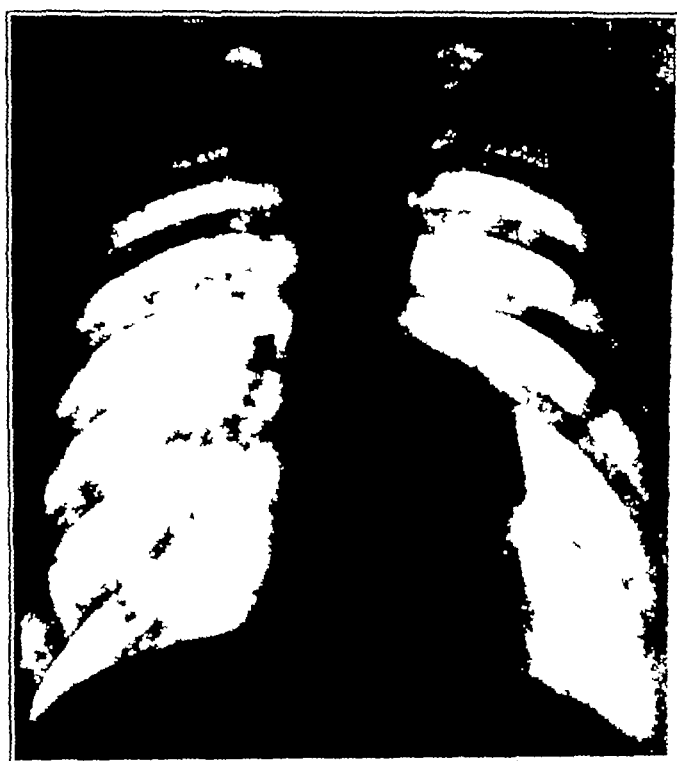


Fig. 1 (case 2)—Complete collapse of the left lung.

time were negative. The tonsils did not appear diseased in spite of a history of attacks of tonsillitis over a period of eighteen years. The trachea is well formed, and both physical and roentgen-ray examination of the trachea is normal.

CASE 2—We report this case through the courtesy of Dr. J. J. A. St. Luke's Hospital, Bluefield, W. Va. J. W., aged 29, a tall, thin, well-developed, appearing man without symptoms of any kind at this time. His family history is irrelevant and his personal history prior to his present illness is not of any particular interest. In August, 1924, he had a spontaneous pneumothorax. A roentgen-ray examination at St. Luke's Hospital showed complete collapse of the left lung. On September 9 roentgen-ray examination showed the left lung completely reexpanded with a small amount of fluid in the pleural space.

1,000 cases in Chicago, 1916, showed vault fractures, 33 per cent, basal fractures, 34 per cent and combined fractures, 33 per cent. In 1923, Brown and Strecker<sup>6</sup> reported 100 cases in Philadelphia, of which 49 per cent were fractures of the vault and 30 per cent were basal fractures. The probable explanation for our relatively low percentage of basal fractures is that we have not, as a routine, taken the large number of special roentgen-ray positions to bring out basal fractures used by Stewart,<sup>7</sup> and our rate of postmortem examinations has been small as most of the cases were done by coroners' physicians. The point, however, is more or less an academic one, as the factor of real importance is the damage to the internal structures. The fracture of the skull is secondary except when it is compound, depressed or stellate with driving in of bone fragments, and when it tears across an important blood vessel or into an infected sinus.

We have adhered to the old classification of cerebral injuries: concussion, contusion, laceration and laceration and hemorrhage. This

TABLE 3—*Clinical Diagnosis*

	Concussion	Contusion	Laceration and		Totals
			Laceration	Hemorrhage	
Without skull fracture	257	7	5		269
With skull fracture	94	24	49	5	172
Totals	351	31	54	5	441

method of classification is inexact, being based mostly on the clinical signs and the course of the condition. Classifications based on observations of the spinal fluid, such as Rodman and Neubauer's<sup>8</sup> and Jackson's,<sup>9</sup> are probably more exact as to limits, but we have not used them as yet. Table 3 shows the cases according to our classification. The term "concussion" has been used rather broadly, and perhaps includes some cases in which the condition might have been classed as "contusion." The rather large number of cases from this group which had unfavorable sequelae would tend to support this supposition.

6 Brown, H. P., and Strecker, E. A. Some Observations in the Treatment of Fractures of the Skull, *Ann Surg* 79: 198, 1924.

7 Stewart, J. W., and Lockett. Skull Fractures, *Annals of Roentgenology*, New York, Paul B. Hoeber, 1925, vol. 6.

8 Rodman, J. S., and Neubauer, B. B. A Plan of Management of Cranial Injuries Based on a New Grouping of Such Injuries, *Am Surg* 79: 481 (April) 1924.

9 Jackson, Harry. The Management of Acute Cranial Injuries by the Early Exact Determination of Intracranial Pressure and Its Relief by Lumbar Puncture, *Surg Gynec. & Obst* 34: 494 (June) 1922.



Fig. 1. Roentgen-ray. Spontaneous pneumothorax on the right side with some consolidation.

Examination of the patient revealed a well-nourished, deep-chested man, with no previous and no lung 150 pounds (68 Kg.). Expansion was restricted at the base of the right lung. The percussion note was apparently normal. Auscultation revealed almost total absence of breath sounds over the right side of the chest anteriorly and posteriorly. No rales were heard in the left lung. The heart, nose, teeth, pharynx, larynx, sputum and urine were normal; the Wassermann reaction was negative. The results of roentgen-ray examination were the same as those shown in figure 1. We concurred in Dr. Whitman's diagnosis and advised treatment at a sanatorium. The lung expanded completely, and we could find no evidence of pulmonary pathologic changes. We then concluded that the collapse was the result of a rupture of a subpleural tubercle. On July 29 the right lung again collapsed, and we decided to inject enough air to maintain a zero manometric reading, hoping



7 Edema and ecchymosis of the scalp in such areas as the mastoid (Battle's sign) indicate a fracture underneath, but in other regions this sign is unreliable. Hematomas have often been wrongly diagnosed as depressed fractures.

8 The deep reflexes are usually affected early and help to localize the side on which the lesion is located, particularly if there are corresponding changes in the motor and sensory functions.

9 Changes in the motor and sensory functions and pathologic toe signs, the Babinski and other signs, usually occur later, if they appear early, they signify a serious lesion.

*Later Neurologic Signs*—1 Steadily deepening unconsciousness after a "lucid interval" usually means intracranial hemorrhage. Localized laceration with edema can closely simulate the picture but is usually

TABLE 4—Roentgen Ray and Clinical Diagnosis

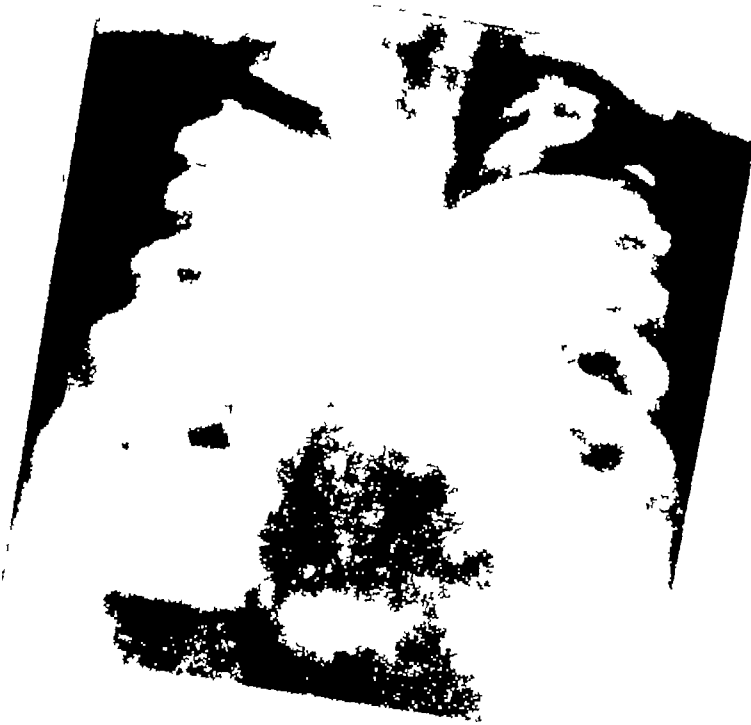
Roentgen Ray Examination	Clinically Positive Fractured Skull				Clinically Negative Fractured Skull				Total Cases		Per centage of Total Cases
	Roentgen Ray Positive		Roentgen Ray Negative		Roentgen Ray Positive		Roentgen Ray Negative		Roentgen Ray Positive	Roentgen Ray Negative	
	No	%	No	%	No	%	No	%			
	117	33.1	88	10.7	10	2.8	189	53.4	127	227	
Made											
		165				199			354		
		34				53			87		19.7
Not made or not reported											
		189				252			441		100
Totals											
Percentage of total		42.8				57.2					100

slower in developing and clears up more promptly, and, unlike hemorrhage, responds more or less favorably to hypertonic treatment.

2 Changes in the eyes are extremely significant and should be observed at frequent intervals in serious cases. In our series, the pupils dilated on the side of lesion, and all patients with dilated or fixed pupils died. Nystagmus is an unfavorable sign. Choked disks are usually a late manifestation, but engorged veins and a haziness of the margins of the disks show the earlier stages of compression.

3 Involvement of the cranial nerve occurs early or late and is permanent or temporary, depending on whether the nerve is severed or merely compressed by accumulated fluids. The sixth nerve is reported as being most frequently involved. In our series, the eighth and seventh nerves were most often affected.

4 Progressive motor or sensory changes are important and indicate partial pressure or complete severance of pathways. The early hyper-tonus and later irritability give way to spasticity and then to weakness and flaccid paralysis in the terminal stages.



clinical symptoms. A negative roentgenogram is not proof that the skull has not been fractured, because the technic may be faulty or the picture may have been taken at an improper angle. One picture may be sufficient, but several are usually necessary to show the details. Clinical observations are of more importance than roentgenograms, except in depressed fractures. Figures 1, 2 and 3 show serious injury, the patients recovered completely.

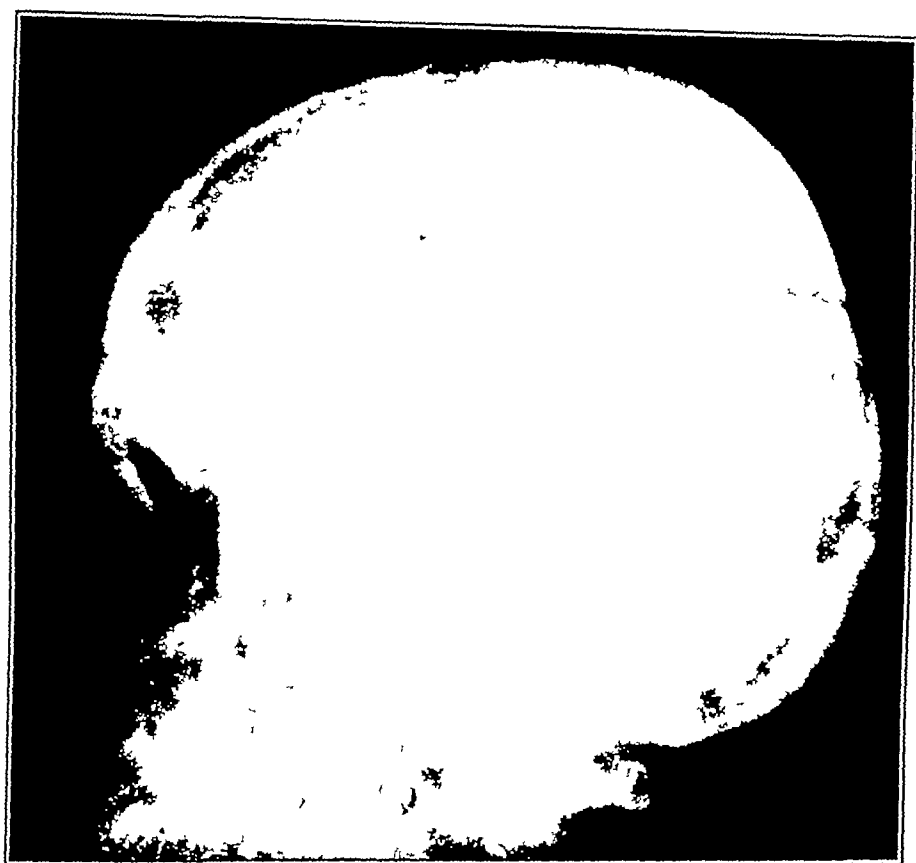


Fig 2—Roentgenogram showing multiple fractures of the occiput with depression in a janitor, aged 40, who was knocked to the pavement by an automobile. He was unconscious a week, and irrational three weeks. He recovered completely and without sequelae.

*Lumbar Puncture*—Lumbar puncture is another fairly accurate diagnostic means and usually indicates the presence of blood, freedom of communication and the intracranial pressure (except when there is a block). It is also a valuable therapeutic agent for relief of pressure and for drainage in infections. The observations on spinal puncture may be unreliable and the drainage dangerous in basal injuries in which there is interference with free communication. We advocate its use only when there is a definite indication, but it should always be done slowly and cautiously. Punctures were made 382 times in 148 cases, or in 33.6



Sharpe,<sup>12</sup> Hendon,<sup>13</sup> Kerr,<sup>14</sup> Mixer<sup>15</sup> and others to prove that surgical decompression lowers the mortality rate. On the other hand, Connors<sup>16</sup> and Munroe<sup>17</sup> and others have quoted figures in favor of the conservative form of treatment. This divergence of opinion would seem to indicate that there is much yet to learn in this regard. The publication of more critical analyses of large series would tend toward the solution of this problem.

We shall give briefly our plan of management, touching on only some of the most important points.

*Immediate Case*—1 History of Accident and Injury. We stress the importance of obtaining and recording the data in detail from as reliable sources as possible. In this way we may know whether or not to

TABLE 5—*Lumbar Punctures (Clinical Groups, Pressures and Results)*

Spinal Fluid	Clinically	Num ber of Lum bar Punc tures Done	Num ber of Punc tures	Aver age Punc ture Pa tient	Cases Listed According to Pressures (Mm of Mercury)				Cases Listed According to Results				Per centage of Deaths in Cases Punc tured
					0 to 10	11 to 20	21 to 30	Over 30	Cured	Not Im proved		Died	
										Im proved	not Treated		
Bloody	Not severe	4	4	1	2	2			3	1			
	Moderately severe	140	40	3.5	15	18	7		23	10	3	4	10
	Severe	79	15	5.3		9	4	2	2	2		11	73.5
	Total cases	223	59									15	
	Percentage		39.9									25.4	
Clear	Not severe	49	41	1.2	25	6			29	10	2		
	Moderately severe	103	44	2.3	15	21	4	1	21	17	1	2	4.5
	Severe	7	4	1.7	3		1		2	1		1	2.1
	Total cases	159	89									3	
	Percentage		60.1									3.4	
Grand totals		382	148	2.6	Percentage of total cases punctured				33.6				28.8

anticipate a depressed, stellate or penetrating fracture. From the medico-legal aspect accurate details are essential. We inquire as to whether there has been a previous fracture or epilepsy and what treatment has been administered before admission.

12 Sharpe, William. Observations in the Diagnosis and Treatment of Brain Injuries in Adults, *J. A. M. A.* **66** 1536 (May 13) 1916, *Diagnosis and Treatment of Brain Injuries*, New York, J. B. Lippincott Company, 1920.

13 Hendon, G. A. Acute Injuries of the Brain, Kentucky *M. J.* **22** 505 (Nov.) 1924.

14 Kerr, H. H. Management of Fractures of Base of Skull, California State *J. Med.* **21** 477 (Nov.) 1923.

15 Mixer, W. J. Fractures of the Base of the Skull at Massachusetts General Hospital, Boston *M. & S. J.* **177** 518 (Oct.) 1917.

16 Connors, J. F. Management of Intracranial Injuries with or without Fracture, **81** 501 (Jan.-June) 1925.

17 Munroe, Donald. Therapeutic Value of Lumbar Puncture in Treatment of Cranial and Intracranial Injury, Boston *M. & S. J.* **193** 1187 (Dec.) 1925.

# CONSTITUTION OF THE AMERICAN ASSOCIATION FOR THORACIC SURGERY

(Adopted May 10, 1927)

## ARTICLE I—NAME

SECTION 1—This Association shall be known as the American Association for Thoracic Surgery

## ARTICLE II—OBJECT

SEC 1—The object of the Association shall be to encourage and stimulate investigation and study that will increase the knowledge of intrathoracic physiology, pathology and therapy, to correlate such knowledge and disseminate it

SEC 2—To attain this object, the Association shall hold at least one scientific meeting every year in which free discussion shall be featured, shall publish annually the transactions of that meeting, shall cooperate with other organizations working toward the same end, and shall undertake such other activities as the Council or the Association as a whole may decide

## ARTICLE III—MEMBERSHIP IN CONGRESS

SEC 1—As a component member of the Congress of American Physicians and Surgeons, this Association subscribes to the Constitution and By-Laws of the Congress

## ARTICLE IV—MEMBERSHIP

SEC 1—There shall be four classes of members Active, Associate, Senior and Honorary Admission to membership in the Association shall be by election Membership shall be limited, the limits on the respective classes to be determined by the By-Laws

SEC 2—Election to Active, Senior and Honorary Membership shall be for life, subject to the provisions of Sec 3, following Election to Associate Membership shall be for a limited period of time, within which time the Associate Member must either demonstrate his eligibility to Active Membership, or, automatically and without further action by the Association as a whole, cease to be a member of the Association. Such period of time shall be determined by the By-Laws The Council shall be vested with full and final power to determine the eligibility of Associate Members for advancement to Active Membership

SEC 3—Membership may be voluntarily terminated at any time by members in good standing The Council, acting as a Board of Censors, may recommend the expulsion of a member on the grounds of moral or professional delinquency, and submit his name, together with the grounds of complaint, to the Association as a whole at any of the regularly convened meetings, after giving the member so accused ample opportunity to appear in his own behalf

## ARTICLE V—OFFICERS AND GOVERNMENT

SEC 1—The officers of the Association shall be a President a Vice President a Secretary, a Treasurer, and five Councilors These nine officers and councilors shall be the governing body of the Association, and shall have full power to act in all matters, except as follows

1 They may not alter the initiation fees or annual dues, nor levy any general assessments against the membership, except that they may, in individual cases, remit annual dues or assessments

significance of the various changes that occur in the four stages of medullary compression. The pressure must be relieved before the onset of medullary exhaustion. Danger signs are exhibited when the pulse pressure is as high as the pulse rate, or when there is a steadily rising pulse rate and blood pressure with a deepening unconsciousness or restlessness. Unfavorable signs are dilating and later fixed pupils, diminishing and later absent deep reflexes, spasticity, clonus, high temperature and a progressively deepening coma. We are on the lookout for unilateral changes in reflexes and corresponding motor and sensory changes. In basal fractures, signs of meningeal irritation mean hemorrhage or infection. Neurologic checks are performed when the patient is discharged and each time he returns during the period the case is followed up.

4 In the early stages, we do not use morphine as a sedative or homatropine as a mydriatic for fear of masking important signs. Codein, aspirin or phenobarbital are usually sufficient and not harmful. If the restlessness is extreme, however, and the danger of hemorrhage is past, the sodium salt of phenobarbital can safely be administered hypodermically, from 1 to 3 (0.065 to 0.00195 Gm.) grains, paraldehyde 1 to 2 drachms (3.75 to 7.5 cc.) by mouth or 2 to 4 (7.5 to 15.0 cc.) by rectum, given carefully in water, or sedative packs.

5 Lumbar puncture is one of the most valuable diagnostic and therapeutic means, it is used in all cases in which the diagnosis is uncertain, and therapeutically for cerebral compression. It is dangerous when the patient is in a state of shock and when there is a block at the base and high pressure above. In the latter condition, ventricular puncture is a safer method of drainage. Lumbar puncture is performed slowly, the pulse rate, respirations, color and blood pressure of the patient being noted. The patient is in the lateral prone position, and the pressures are taken with a standard mercury manometer. The amount of fluid removed depends on the conditions. If removal produces unfavorable signs, the pressure is read and only a few drops of fluid are removed to determine the color. We usually remove a sufficient amount to reduce the pressure to half of what it was originally. Therapeutic punctures are repeated as indicated. In our series (table 5), the number of punctures per patient was 2.5, the procedure without doubt saved many. Jackson<sup>9</sup> strongly advocated its use and felt, as we do, that it is a more reliable guide than vital signs and blood pressure. Green<sup>18</sup> and Holbrook<sup>19</sup> also advocated strongly the use of lumbar puncture. Besley,<sup>5</sup> on the other hand, pointed out with good reason that if puncture is performed too frequently it may cause an excessive secretion of spinal

18 Green, T. M. Management and Treatment of Brain Injuries, *Internal Clinics* 2:239 (June) 1924.

19 Holbrook, F. C. The Diagnosis and Management of Head Injuries, *J. A. M. A.* 83:489 (Aug. 16) 1924.

be held intact as an Endowment Fund. The Council is responsible for the proper management of the Endowment Fund. The income from this fund may be utilized for such purposes as may be determined in the By-Laws. If at the end of any fiscal year there be a surplus in the current fund of the Association, the Council may divert such surplus into the Endowment Fund but in no case may the Council divert any of the principal of the Endowment Fund into the current account of the Association.

In the event of the dissolution of the Association, the Endowment Fund shall be distributed among national institutions of the United States and Canada in a proportion equal to the then existing ratio between the numbers of citizens of the two nations who are members of the Association.

#### ARTICLE VIII MEETINGS

SEC. 1. The time, place, duration and procedure of the annual meeting of the Association shall be determined by the Council, subject only to the requirement of the Congress of American Physicians and Surgeons, and the provision of the By-Laws.

SEC. 2. A special meeting of the Association may be called on one month's notice on the written request of fifteen members. The specific purposes of the meeting must be stated in the request and in the official call for the meeting.

SEC. 3. The annual meeting of the Council shall be held during January.

#### ARTICLE IX AMENDMENTS

SEC. 1. This Constitution shall in no wise be changed except by a three-fourth vote of the members present at an annual meeting, and further provided that the proposed alteration or amendment shall have been moved and seconded at a previous annual meeting, and that printed copies of the suggested alteration or amendment shall have been circulated among the members and that the members shall have been specifically advised that such alteration or amendment will be voted upon.

### BY-LAWS

#### ARTICLE I

SEC. 1. These By-Laws shall merely interpret the Constitution and practically apply its principles. They shall set forth no principle not included in the Constitution.

#### ARTICLE II

SEC. 1. All papers read before the Association shall become the property of the Association. Authors shall leave original copies of their manuscripts with the Secretary at the time of presentation.

SEC. 2. When the number of papers makes it desirable the Council may require authors to present their papers in abstract, and may set a time limit on discussion.

#### ARTICLE III

SEC. 1. The Secretary shall, at the conclusion of the annual meeting of the Association, certify to the Secretary of the Congress of American Physicians and Surgeons, the names of all officers for the ensuing year, all changes in membership, and all changes in the Constitution and By-Laws.



an infected sinus and for late epilepsy with a localized depression. It does not seem necessary to elaborate on the technic of decompression. Cushing's time honored subtemporal approach by splitting the temporal muscle is the best. The dura is opened only if there is blood or accumulated fluid underneath, and is not drained unless it seems necessary. We agree with Heuer<sup>20</sup> and Bower<sup>21</sup> that subdural drainage should be avoided if possible because of the danger of infection, but it is definitely indicated at times and may save life. Exploration and drainage of a frontal sinus may be indicated if the fracture has probably torn the dura and extended into an infected sinus, this also applies to an aerocele from a fracture into the paranasal air cells. As a comparison to our experience, Sharpe<sup>12</sup> performed operations on 30 per cent, Stewart<sup>4</sup> on 28 per cent, Wilensky<sup>22</sup> on 24 per cent and Naffziger<sup>23</sup> on about 20 per cent of the patients, with mortalities ranging from 39 to 51.7 per cent. Operation was performed in twenty-two of our cases, or 43 per cent, fourteen patients died, giving an operative mortality of 59.1 per cent. In practically all of the fatal cases, it was found that extensive injuries were present besides that for which the operation was performed. This and the fact that so many patients whose condition was serious recovered by means of nonsurgical measures explains the operative mortality rate which is a little higher than in most of the other series. On the other hand, our mortality rate for the whole series was 14.7 per cent, which is the lowest of all except Hendon's<sup>18</sup> of sixty-three cases with 6 per cent and Munroe's<sup>17</sup> of ninety-nine cases with 14 per cent.

*After-Care*—There can not be any hard and fast rules concerning the after-care of these patients, as each case presents a different problem. An essential in all is absolute rest for a sufficient period to assure return to normal and then a gradual return to active life. Our custom has been to keep patients in bed for from one to four weeks or longer, we then gradually permit them to be up and around during a period of from one to two weeks and instruct them to lead an easy life for from one to two months longer. In this way, they return to light work in from one to three months after injury and do regular heavy work after from one to three months more. Jackson,<sup>9</sup> Krause<sup>24</sup> and Sharpe<sup>25</sup> advocated

20 Heuer, G. I. Fracture of the Skull, *J. A. M. A.* **82** 1467 (May 3) 1924

21 Bower, John O. Management of Injuries to the Cranium and its Contents *Ann. Surg.* **78** 433 (Oct.) 1923

22 Wilensky. Fracture of Skull with Special Reference to Its Neurological Manifestations, *Ann. Surg.* **70** 404 (Oct.) 1919

23 Naffziger, H. C. Head Injuries—Indications for Surgical Treatments, *S. Clin. N. Amer.* **3** 699 (June) 1923

24 Krause, Charles. Standardization of Treatment of Skull Fracture *J. Iowa M. Soc.* **15** 181

25 Sharpe, William. Recent Advances in Neuro-Surgery—Diagnosis and Treatment of Brain Injuries, *Rhode Is. and M. J.* **8** 51 (April) 1925

SEC 3—The Secretary of the Association shall perform all duties customarily pertaining to the office of Secretary. He shall not only serve as Secretary of the Association but also as Secretary of the Council. The Secretary shall be elected from the Active Members of the Association.

SEC 4—The Treasurer of the Association shall perform all duties customarily pertaining to the office of Treasurer. He shall not only serve as Treasurer of the Association but shall also serve as custodian of the Endowment Fund. The Treasurer shall be elected from the Active Members of the Association.

SEC 5—The Councilors of the Association shall hold office as specified in the Constitution. They may be elected from either the Active Members or the Senior Members of the Association.

SEC 6—In the event of a vacancy occurring in the office of President, the Council shall advance the Vice President to the Presidency and appoint a new Vice President under the provisions of Article V, Section 3 of the Constitution.

#### ARTICLE VI

SEC 1—The Nominating Committee shall consist of three Active or Senior Members elected in accordance with the provisions of Article VI, Section 1, of the Constitution. The Council shall instruct the Committee as to the vacancies which are to be filled by election.

SEC 2—The Membership Committee shall consist of five Active or Senior Members appointed in accordance with the provisions of Article VI, Section 2 of the Constitution. The Council may appoint not more than one of its own members to serve on this Committee. The duties of the Membership Committee are to investigate all candidates for membership in the Association and to report their findings as expeditiously as possible to the Council through the Secretary of the Association. This Committee is also charged with searching the literature of this and other countries to the end that proper candidates may be presented to the Association for consideration. Appointment to this Committee shall be for a period of one year, and not more than three of the members may be reappointed to succeed themselves.

SEC 3—The Auditing Committee shall consist of three Active or Senior Members appointed in accordance with the provisions of Article VI, Section 2 of the Constitution. None of these may be selected from the officers or councilors of the Association. Their duty shall be to audit the accounts of the Association at the end of each fiscal year, and render their report to the Council of the Association through the Secretary. Appointments to this Committee shall be made for a one year term. Not more than two members may be reappointed to succeed themselves.

SEC 4—The Committee on Program and Transactions shall consist of four members. The President of the Association, the Secretary of the Association and two members at large. One member at large shall be resident at or near the place of annual meeting. The other member at large shall be appointed on the recommendation of the President, to serve as Secretary of the Program Committee. The duties of this Committee shall be to arrange in conformity with instructions from the Council, the scientific program for the annual meeting, to collect all papers presented and procure the publication of the transactions and proceedings.

SEC 5—The Necrology Committee shall consist of three active or senior members, and shall be appointed in accordance with the provisions of Article VI, Section 2. Appointments to this Committee shall be for a one year term.

Sharpe<sup>12</sup> attempted such a survey and heard from 34 per cent of his patients, 68 per cent showed unfavorable symptoms. Hoag<sup>26</sup> stated that subjective symptoms are present in 80 per cent of the cases of injuries of the head, and that of these 8 per cent are psychic. When the compensation factor enters in, it is difficult to evaluate fairly the

TABLE 8—Cause of Death

Head Injuries	Hemor- rhage	Lacera- tion	Lacera- tion and Hemor- rhage	Oper- ation and Lacera- tion Hemorrhage	Menin- gitis	Pneu- monia	Myo- cardial Failure	Totals
Not serious				1				
Serious	2	11	35	9	4	1	1	3
Totals	2	11	35	10	4	2	1	65

TABLE 9—Our Summary and Others Some in Recent Literature

Author	Year	No of Cases	Aver- age Age	Trauma, %	Site %	Opera- tions, %	Operative, Mor- tality, %	Total Mor- tality, %	Sequelae %
Besley	1916	1,000	42+	Fall 38 Blow 31	Vault 33 Base 34 Combined 33		1	53	
Sharpe	1916	239						30.7	67 of 34 return cases
Wilensky	1910	72	54			24	48	31	
Moorhead and Weller	1921	100	6½			12		26	
Stewart	1921	6,135 total 617 fracture skulls	36	Fall 33 Auto 24 Blow 22	Vault 63 Base 34	28	51.7	52	55
Bower	1923	62						26.1	
Brown and Strecker	1923	100			Vault 47 Base 30	17	35.3	26	
Heuer	1924	223				23.8	41.5	35.8	
Hendon	1924	61 (one hosp) 63 (another hosp)				27 10	40 50	60 6	
Connors	1925	1,100 possible 497 established cases		Series from 1914-1917 Series from 1917-1924		18.8 9.8	34.1 46.1	56.4 48.4	
Sharpe	1925					30 (16% children)	39	33	
Munroe	1925	217 (other hospitals) 99 (his own)				3.2 10	57 33	22 14	
McClure and Crawford	1927	441	30	Auto 54.2 Fall 20 Blow 18.4	Vault 85.7 Base 5.7 Combined 8.6	4.3	50.1	14.7	17.7

organic and functional elements. Stewart<sup>4</sup> found 55 per cent with unfavorable sequelae in his series. In our series 81.5 per cent of the deaths occurred within forty-eight hours after admission. Table 8 shows the causes of death.

26 Hoag, David A. Nervous and Mental Diseases Following Head Injuries, J. A. M. A. 82:1468 (May 3) 1924.

SEC 3—At the annual meeting of the Council the order of business shall be

- 1 Reading of minutes
- 2 Treasurer's report
- 3 Appointment of committees
- 4 Determination of instructions to be given to Auditing, Membership, Necrology and other committees except Program Committee
- 5 Determination of details in connection with the annual meeting
- 6 Appointment and instructions to the Program Committee
- 7 Unfinished Business
- 8 New Business

SEC 4—There shall be not less than two meetings of the Council during the fiscal year of the Association

#### ARTICLE X

SEC 1—These By-Laws shall in no wise be changed except by a two-thirds vote of the members present at the annual meeting or a properly convened meeting of the Association, and further provided that the proposed action or amendment shall have been moved and seconded by not less than three of the members in a properly convened annual or special meeting of the Association

SEC. 2—These By-Laws may be suspended in whole or in part for a period of not more than twelve hours by a unanimous vote of those present at any regularly convened meeting of the Association

## SUMMARY

1 The problem of the proper management of cases of injuries to the head is of increasing importance. Much progress has been made, but an improvement can yet be made on our results.

2 It should be the aim of the medical profession to make more accurate diagnoses of cases so that the appropriate treatment can be applied to each different group. Only in this way can the number of deaths, complications and sequelae be cut down.

3 In the management of cases of injuries of the head stress is laid on (1) the importance of accurate detailed history, (2) careful repeated examinations, (3) constant skilful nursing, (4) the taking of roentgenograms in all cases, (5) spinal punctures for diagnoses in all doubtful cases, when the patient is not in a state of shock and when block does not occur at the base of the cerebrum, and treatment with hypertonics to reduce cerebral compression, (6) properly timed surgical intervention for accessible hemorrhage, compound and depressed fractures and (7) insistence on keeping the patients quiet for a sufficient length of time and a gradual resumption of duties after recovery.

4 We have made a report on our series of 441 cases of craniocerebral injuries because we believe that such publication of critical reviews is of scientific value.

Dr George J Heuer	Cincinnati General Hospital, Cincinnati
Dr Charles Gordon Heyd	116 East Fifty-Third Street, New York
Dr James M Hitzrot	126 East Thirty-Seventh Street, New York
Lt Col William L Keller, M C, U S Army	Walter Reed Hospital, Washington, D C
Dr James H Kenyon	22 East Sixty-Ninth Street, New York
Dr John D Kernan	120 East Seventy-Fifth Street, New York
Dr Adrian V S Lambert	168 East Seventy-First Street, New York
Dr Walter Estell Lee	905 Pine Street, Philadelphia
Dr Willis S Lemon	Mayo Clinic, Rochester, Minn
Dr William Lerche	Lowry Building, St Paul
Dr Leon T LeWald	114 East Fifty-Fourth Street, New York
Dr Howard Lilienthal	52 East Eighty-Second Street, New York
Dr A L Lockwood	164 Bloor Street East, Toronto
Dr Charles D Lockwood	295 Markham Place, Pasadena, Calif
Dr Frederick T Lord	305 Beacon Street, Boston
Dr Urban Maes	1671 Octavia Street, New Orleans
Dr Walton Martin	230 East Forty-Ninth Street, New York
Dr Rudolf Matas	2255 St Charles Avenue, New Orleans
Dr E S McSweeney	132 East Thirty-Sixth Street, New York
Dr Willy Meyer	700 Madison Avenue, New York
Dr James Alexander Miller	379 Park Avenue, New York
Dr Robert T Miller, Jr	9 East Chase Street, Baltimore
Dr James F Mitchell	1344 Nineteenth Street, Washington, D C
Dr Alexis V Moschowitz	925 Madison Avenue, New York
Dr George P Muller	1930 Spruce Street, Philadelphia
Dr Harold Neuhof	4 East Ninety-Fifth Street, New York
Dr Edward N Packard	105 Main Street, Saranac Lake, N Y
Dr C D Parfit	Calydor Sanatorium, on Lake Muskoka, Gravenhurst, Ontario
Dr Edward W Peterson	525 Park Avenue, New York
Dr Edgar W Phillips	80 East Avenue, Rochester, N Y
Dr Otto C Pickhardt	117 East Eightieth Street, New York
Dr Henry S Plummer	Mayo Clinic, Rochester, Minn
Dr E H Pool	107 East Sixtieth Street, New York
Dr Stuart Pritchard	Battle Creek Sanatorium, Battle Creek, Mich
Dr Samuel Robinson	22 West Micheltarena Street, Santa Barbara, Calif
Dr Francis A C Scrimger	Medical Arts Building, Montreal
Dr Arthur M Shipley	University Hospital Baltimore, Md
Dr J J Singer	Washington University Medical School, St Louis
Dr John Smyth	724 Baronne Street, New Orleans
Dr De Witt Stetten	850 Park Avenue, New York
Dr David A Stewart	Ninette, Manitoba
Dr George A Stewart	2427 Madison Avenue, Baltimore
Dr William H Thearle	633 Republic Building Denver
Dr Franz Torek	1021 Madison Avenue New York
Dr Philemon E Truesdale	151 Rock Street, Fall River Mass
Dr Gabriel Tucker	University Hospital, Bronchoscopic Clinic, Philadelphia
Dr Porter P Vinson	Mayo Clinic, Rochester Minn
Dr Everett E Watson	Mount Regis Sanatorium, Salem Va
Dr Gerald B Webb	Colorado Springs, Colo
Dr Edward S Welles	20 Church Street Saranac Lake N Y
Dr Allen Whipple	41 East Seventieth Street New York

## SYMPTOMS

The symptoms of arteriovenous aneurysm can be conveniently divided into local or regional, and cardiovascular or systemic

*Local Symptoms*—In the region of the fistula there is a continuous bruit and a purring thrill throughout the cardiac cycle with systolic intensification. These sounds are transmitted distally and proximally along the lines of the veins. The thrill is pathognomonic, it is present in all cases of arteriovenous aneurysms and is most marked at the site of the lesion. It is felt as a humming or buzzing sensation and has been likened to the vibrations of a bee in a paper bag. Often venous pulsations are visible, but this together with the murmur and thrill, disappear when the fistula is closed by digital pressure. A tumor may or may not be present. The superficial veins distal and proximal to the lesion are engorged and tortuous. In some of the cases in the present series, operation for varicose veins had been performed previously. The circumference of the limb is often greatly increased, and in the congenital cases the limb is actually lengthened. The surface temperature in the region of the fistula is increased from 2 to 3 C, while in the distal parts it is lower than that of its fellow. Blood taken from the veins near the site of the aneurysm is high in oxygen content, and may be equivalent to that of arterial blood. In the distal part of the limb there may be trophic changes such as gangrene and varicose ulcers. Owing to the venous engorgement, the patient may complain of weakness, of a feeling of heaviness and numbness and a sense of weight in the limb. In many instances an elastic bandage is necessary for relief.

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4 Reid, M R. Studies of Abnormal Arteriovenous Communications, Acquired and Congenital. I. Report of a Series of Cases, *Arch Surg* **10** 601 (March) 1925, Abnormal Arteriovenous Communications. II. The Origin and Nature of Arteriovenous Aneurysms, Cirroid Aneurysms and Simple Angiomas, *ibid* **10** 996 (May) 1925, Abnormal Arteriovenous Communications. III. The Effects of Abnormal Arteriovenous Communications on the Heart, Blood Vessels and Other Structures, *ibid* **11** 25 (July) 1925, Abnormal Arteriovenous Communications. IV. The Treatment of Abnormal Arteriovenous Communications, **11** 237 (Aug) 1925.

5 Holman, Emile. The Physiology of Arteriovenous Fistula, *Arch Surg* **7** 64 (July) 1923, Arteriovenous Aneurysm, *Ann Surg* **80** 801, 1924, Experimental Studies in Arteriovenous Fistulas, *Arch Surg* **9** 822 (Nov) 1924. Holman, Emile and Edwards, M E. A New Principle in the Surgery of the Large Vessels. Ligation of Vein Proximal to Site of Ligation of Artery, *Experimental Studies*, *J A M A* **88** 909 (March 19) 1927.

6 Hoover, C F, and Beams, S J. The Diagnosis and Pathologic Physiology of Arteriovenous Aneurysm, *Arch Int Med* **33** 1 (Jan) 1924.

7 Lewis, T, and Drury, A N. Observations Relating to Arteriovenous Aneurysms, Circulatory Manifestations in Clinical Cases with Particular Reference to Arterial Phenomenon of Aortic Regurgitation, *Heart* **10** 301, 1923.

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## THE MANAGEMENT OF CRANIOCEREBRAL INJURIES \*

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AND

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DETROIT

During the past decade a number of valuable papers dealing with craniocerebral injuries have appeared. The importance of this problem is being realized more and more in this era of great industrial expansion with the congestion of rapidly growing cities and the constant increase in the speed of travel. Reports of critical analyses of series of cases have helped to make the important features of the diagnosis more clear, and a more effective management of cases of injury to the head has gradually evolved. In spite of this improvement in results, members of the medical profession should strive to do better, and their experience should be made available to others.

We report a series of 441 cases of craniocerebral injuries in which the patients were treated in our hospital during a period of a little over ten years. Only cases of injury to the cranium or cranial contents are included in this series, all questionable cases of concussion and simple injury to the scalp being omitted. Our series probably represents fairly well the experience in an average general hospital in a large rapidly growing industrial city. The cases come from both industrial and civil life, and a fairly large number have been followed in the outpatient department until the patient has been entirely cured. An effort has been made to keep in touch with the other patients by letter.

An attempt has not been made to record all the collected data and only those observations are given which may have some practical value in diagnosis and treatment.

### GENERAL DATA

For the sake of a background, we have made an attempt to secure some general data regarding injuries to the head in industrial and civil life in the United States. In regard to the incidence of injuries of the head the available figures are of interest. In 1927 the United States Department of Labor Bureau of Labor Statistics<sup>1</sup> reported that in 1917

\* From the Surgical Department of the Henry Ford Hospital

1 Bull 425, Bureau of Labor Statistics, U S Dept of Labor 1927



dilatation and not hypertrophy Experimentally, Holman has shown that the total volume of circulating fluid is increased, that venous pressure is increased in the veins proximal to the lesion and that hypertrophy as well as dilatation of the heart results In case 16, the total volume of blood before operation for closure of the fistula was 108 cc for each kilogram of body weight, whereas after the operation it decreased to 85 cc, which is considered normal

The effect on the cardiovascular system of an arteriovenous aneurysm is similar in some respects to that of aortic regurgitation In the latter condition, however, the arterial leak is limited to diastole, whereas in a fistula the leakage occurs throughout the entire cardiac cycle The systolic pressure is normal or slightly above normal, thus presenting a high pulse pressure, and the diastolic pressure is considerably below normal The temporary closing of the fistula by digital pressure is followed by an immediate rise in systolic as well as diastolic pressure, the latter always more marked The permanent closure of the fistula results in the restoration of the pressure to normal The blood pressure in the limb distal to the anastomosis is obviously greatly diminished and below that of its fellow The pulse is of the water-hammer type, and frequently capillary pulsation is visible The heart beat is forceful, often heaving Cardiac murmurs are frequently present

The rate of the heart is usually increased In the cases in this series of acquired arteriovenous fistulas in which any enlargement of the heart or of the proximal artery was noted, the heart rate was 64, 90, 62, 72, 92, 76 and 92 Closure of the fistula is followed by an immediate drop in rate, often as much as forty beats each minute (Branham bradycardia sign) This phenomenon is readily explained The stoppage of the arterial leak restores to the circulation the normal resistance of the capillary bed, which, in face of the increased total blood volume produced in consequence of the compensatory mechanism to maintain general blood pressure in the presence of the circulatory short circuit, results in the sudden elevation of the arterial pressure with dilatation of the aorta The vagal depressor fibers are thereby stimulated and an immediate slowing of the cardiac rate follows That this is the result of vagal stimulation is conclusively proved by the abolition of the phenomenon if the patient has previously been given atropine for physiologic effect When the fistula is closed permanently, the readjustment of the circulation, as evidenced by the gradual return of the blood pressure and the cardiac rate to normal is accomplished mainly by the diminution of the total blood volume

There was definite evidence of cardiac change in nine of the twenty-five patients in this series

The artery leading to the fistula is often enormously dilated, thin-walled, tortuous and heaving In two cases of arteriovenous fistula of

might well be brought out in future reports from other large hospitals in this and all large cities. The next most frequent cause of injury were falls, 20 per cent, and blows, 18.4 per cent. The ratio of males to females in the whole series was 3 to 1, and the number of males varied in the different groups from 63 per cent injured by automobiles, to 88 per cent by falls and 96 per cent by blows. As to age incidence, persons in the first four decades were most affected. The average age for the series was 30. In 1921, Stewart<sup>4</sup> reported 6,135 cases of injuries of the head in New York City, of which 617 consisted of fractured skulls. In this series, 65 per cent were men, and the average age was 36.

TABLE 1—*Traumatic Agents (Age and Sex)*

Age (Decades) Years	Auto mobile		Fall		Blow		Street Car		Train		Gun shot		Foreign Body		Not Classified		Totals		(Both Sexes)
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	
0 to 10	38	17	17	4	1	2									1		57	23	80
11 to 20	19	11	6	1	3										2		30	13	43
21 to 30	29	25	23	3	23	1	2	1			1		1		5		84	30	114
31 to 40	28	10	16	1	29		3	2	1						2	2	79	15	94
41 to 50	20	11	5		12		1	1							1		39	12	51
51 to 60	4	7	8		9										1		22	7	29
61 to 70	10	7	1	1			2	2							1		14	10	24
Not recorded	3		2		1												6		6
Totals	151	88	78	10	78	3	8	6	1		1	1	1		13	2	331	110	
Totals (both sexes)	239		88		81		14		1		2		1		15		441		441
Percentage of 441 cases	54.2		20		18.4		3.2		0.2		0.4		0.2		3.4		75		100

TABLE 2—*Location of Injury*

Vertex						Basal	Combined Vertex and Basal	
Right Tem- poral Lobe, Partial	Left Tem- poral Lobe, Partial	Occiput	Frontal	Both Sides	Not Classified			
58	50	47	82	7	134	25	38	
Total (by location)						378	25	38
Percentage of total series						85.7	5.7	86

## LOCATION AND TYPE OF INJURY

We have classified the fractures of the skull as basal and vault fractures. The latter type is subdivided into fissured (linear and stellate), comminuted, diastatic, depressed and perforated. The location of injury is shown in table 2. 85.7 per cent were in the vertex, 5.7 per cent basal and 8.6 per cent combined. Stewart's series showed fractures of the vault in 66 per cent and basal fractures 3.4 per cent. Besley's<sup>5</sup> series of

4 Stewart, J. W. Fractures of the Skull, J. A. M. A. 77:2030 (Dec. 24) 1921.

5 Besley, F. A. A Contribution to the Subject of Skull Fractures, J. A. M. A. 66:345 (Jan. 29) 1916.

of 29 and 46, respectively. Osler did not appreciate the causal relationship between the two conditions, and counselled against operation in cases of arteriovenous aneurysm. The attitude formerly held by the medical profession, based on the chronicity and often apparent absence of symptoms, that communication between one of the smaller arteries and veins is a relatively benign lesion, has been materially changed, so that today the cardiac injury, chronic invalidism and the shortening of life, are recognized as potential complications of the lesion.

#### TREATMENT

The object of any surgical treatment in cases of arteriovenous aneurysm is to stop permanently the arterial leak without interference with the blood supply of the tissues beyond. The method of accomplishing this may vary according to the type and site of the lesion, the efficiency of the collateral circulation, and the individual predilection of the surgeon.

*Congenital Arteriovenous Aneurysm*—Reid reported a case of congenital arteriovenous aneurysm in which operation revealed one communication between the subclavian artery and vein, although the application of ten ligatures was necessary for cure. In most cases, however, of this kind there are multiple communications between the arteries and veins, and often between the smaller branches. The treatment, therefore, must be directed at the elimination of the mass of dilated vessels and their communications as in cases of superficial cirroid aneurysm, or the affected limb must be amputated. In three cases in the series in which a limb was involved, a maximal thrill could be felt over one of the larger arteries, suggesting that the communication was single, operation was advised with a view of extirpating the fistula. After the vessels were exposed a definite area of anastomosis between the artery and the vein was found and removed, but following this procedure in each case the circulation in the distal parts was definitely diminished, gangrene resulted and amputation of the limb became necessary. Subsequent radiologic examination and dissection of these amputated limbs showed that numerous communications between the arteries and veins were scattered diffusely through the limb. Many of the communications were only minute, their presence precluded the possibility of any effectual surgical treatment other than amputation.

*Acquired Arteriovenous Aneurysm*—In the acquired form of aneurysm there is usually only one communication, and the operative procedure for the extirpation is relatively simple. Unless a pulsating hematoma accompanies the fistula, or the wound is badly infected, it is advisable to wait two or three months before attempting repair. This delay permits healing of the wound and subsidence of the edema of the

## DIAGNOSIS

The diagnosis of the mild and severe cases is fairly simple but there is a certain group in which it is difficult to determine the location and degree of injury in the early stages, and to differentiate the factors of edema, contusion, laceration and hemorrhage. We shall not attempt any comprehensive discussion of the technic of diagnosis, nor a tabulation of the clinical data in our cases, but shall give briefly some of the lessons we have learned and emphasize again some of the aids in diagnosis. We have depended mainly on clinical signs and symptoms, lumbar puncture, roentgen-ray observations and clinical courses.

*Early Signs and Symptoms*—The following signs and symptoms have been valuable guides

1 The degree and duration of the primary unconsciousness has been a fair index to the severity of the injury and the probable course except in cases of secondary hemorrhage and infection. Usually when the unconsciousness lasted several hours or longer convalescence was prolonged and followed by one or more unfavorable sequelae. There were some notable exceptions, some patients with the most severe injuries made a rapid and complete recovery, while others with mild cases of concussion were incapacitated more or less permanently.

2 Such symptoms as shock, vomiting, color and mental state are usually of help in making a diagnosis but they are often unreliable because of the great individual variation in reaction and recovery.

3 The "cracked-pot" percussion note of the skull usually indicates the presence of fracture, but it can be deceptive and should not be relied on too much.

4 The external injury to the scalp usually shows the probable site of deep injury and should warn one against middle meningial hemorrhage or infection from sinuses. Contra-coup injuries however are not infrequent and must always be considered.

5 Blood from the cranial orifices (ears, nose and mouth) indicates basal fracture unless it is due to external trauma.

6 Conditions of the eye such as ecchymosis of the lids and subconjunctival hemorrhage, are more apt to be delayed in onset and persist longer if they are of deep origin than if they are caused by external injury. The pupils are important guides to the severity of the injury and to the side on which the lesion is located. They first contract then gradually dilate, and finally lose the reactions to light. The disks usually do not show changes in the acute stage of the injury. Holman and Scott<sup>10</sup> have emphasized the localizing value of homolateral dilatation and fixation of the pupil.

10 Holman, Emil and Scott, W. J. Significance of Unilateral Dilatation and Fixation of Pupils in Severe Skull Injuries, J. A. M. A. 84 1329 (May 2) 1925

carotid (fig 2) In such cases the communicating tract must be very small to favor closure by clotting. But even so it is difficult to understand how cure is effected unless the slowing of the blood stream through the fistula incident to the ligation of the internal carotid artery is more marked than usual. This might be caused by the additional obstruction to the flow of blood offered by the trabeculations in the cavernous sinus which permits clotting in the fistulous tract before the secondary rise in blood pressure in the carotid after the complete reestablishment of the collateral circulation.



Fig 3 (case 16) —Arteriovenous aneurysm of the left common femoral vessel of six years' duration. The prominence of the tortuous superficial veins, the increased dimensions of the limb, and the presence of the trophic ulcer of the leg may be noted.

One of the most important principles in surgery of the vascular system was not recognized until at the time of the World War, when Sir George Makin pointed out that in case of injury to an important artery the simultaneous ligation of both artery and vein does not give rise to increased risk of gangrene but diminishes it. By obstructing the companion vein also the balance of the collateral circulation is more

5 The deep reflexes usually change correspondingly and help to localize the lesion. The possibility of pathologic reflexes from spinal syphilis and other conditions must be remembered.

6 The vital signs (temperature, pulse and respirations) and blood pressure are indicators of the condition of the medullary centers. These signs should be recorded frequently in the serious cases. Greenleaf<sup>11</sup> has pointed out the localizing value of unilateral elevation of temperature in the axilla opposite the lesion. At times this might be invaluable.



Fig 1—Roentgenogram showing multiple fractures with wide separation and some depression in a policeman, aged 31, who was thrown to the pavement by a runaway horse. The recovery was uneventful with no complications and no sequelae reported.

*Roentgen-Ray Examination*—Roentgenograms give definite information about the skull and should be taken in all cases of real injury of the head. It gives a clue as to whether hemorrhage or infection is apt to occur. Table 4 shows that in our series roentgenograms were taken in 80.3 per cent of the cases and 35.9 per cent of these were positive. In 10.7 per cent of the clinically positive cases the roentgenograms were reported negative and in 2.8 per cent positive in the absence of positive

11 Greenleaf, Paul. *Cranio Cerebral Injuries*. Illinois M. J. 47:46 (Jan.) 1925.

*Examination*—The patient weighed 69 Kg (131 pounds) There was a marked systolic pulsation in the vessels of the neck with slight systolic thrill and murmur over the carotids Cardiac dulness extended 12 cm to the left and 2 cm to the right of the median line, with a precordial heave from the second rib down and a systolic murmur over the whole precordium The point of maximal impulse was heaving and powerful The superficial veins of the left side of the abdomen



Fig 5A

Fig 5 (case 16) —*A* shows the heart before operation, *B*, thirty-one days after operation

and the left inguinal region were dilated and could be followed to the left side of the chest A continuous thrill with systolic intensification could be felt over the left Poupart ligament Capillary pulsation was observed in the fingers The right thigh measured 42 cm, and the left, 53 cm The right calf measured 29.5 cm, and the left, 36.5 cm The left leg was warmer than the right, more

per cent of the total number of cases in our series (table 5) The fluid was bloody in 39.9 per cent of the cases in which puncture was performed and clear in 60.1 per cent In table 5 the cases are grouped clinically according to the three degrees of severity and also according to the pressures As would be expected, 83.3 per cent of the cases in which death occurred showed bloody fluid Stewart<sup>7</sup> reported punctures in 26 per cent of his cases with bloody fluid in 90 per cent Jackson<sup>8</sup> classified his injuries according to spinal fluid pressure as follows 14 per cent with pressures over 30 mm of mercury, 34 per cent from

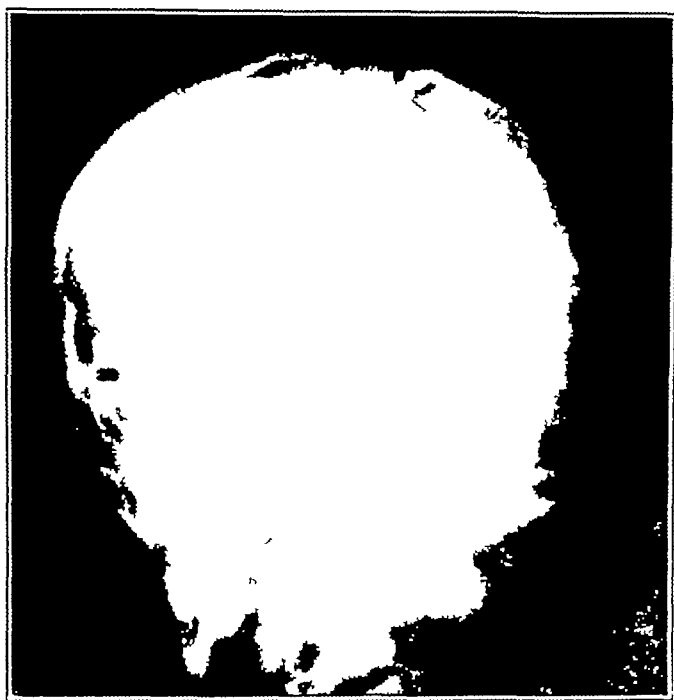


Fig 3--Roentgenogram showing the depressed fracture of the right parietal area in a boy, 3 years of age, who fell 27 feet A complete recovery without sequelae is reported

20 to 30 mm, and 44 per cent, from 10 to 20 mm In our series 47.3 per cent had pressures under 10 mm, 39.8 per cent from 11 to 20 mm 10.8 per cent from 21 to 30 mm and 2 per cent above 30 mm

#### TREATMENT

Some of the earliest operations on the brain were doubtless performed to relieve the pressure from hemorrhage Trephination for this purpose was practiced during the early centuries Until recently, surgical treatment in most of the serious cases was advocated and practiced but now there is a definite tendency toward conservatism There seems to be a general agreement as to nonsurgical treatment in the mild uncomplicated and moribund cases but there is still some difference of opinion regarding cases of cerebral compression Statistics are quoted by



volume The plasma volume for each kilogram was 70 cc, the total volume being 4,857 cc The whole blood volume for each kilogram of body weight was 108 cc (normal 85), the total volume was 7,462 cc Subsequently, the blood pressure of the left leg with the fistula open was 140 systolic and 40 diastolic, with the fistula closed it was 185 systolic and 80 diastolic The pulse rate was 90 with the fistula open and 60 with the fistula closed The temperature of the left thigh was 3 C warmer than the right The oxygen content of the venous blood of the left thigh was 18 volumes per cent, equal to the arterial blood, its oxygen capacity was 232 per cent by volume The blood volume for each kilogram of body weight was 108 cc, the total volume was 7,462 cc

The diagnosis was arteriovenous aneurysm of the left groin

*Operation and Course*—On March 1, 1926, I excised a segment of the femoral artery and vein, including the fistula, and placed quadruple ligatures on the left femoral artery immediately below Poupart's ligament The first incision was made just above and parallel to Poupart's ligament The external iliac artery

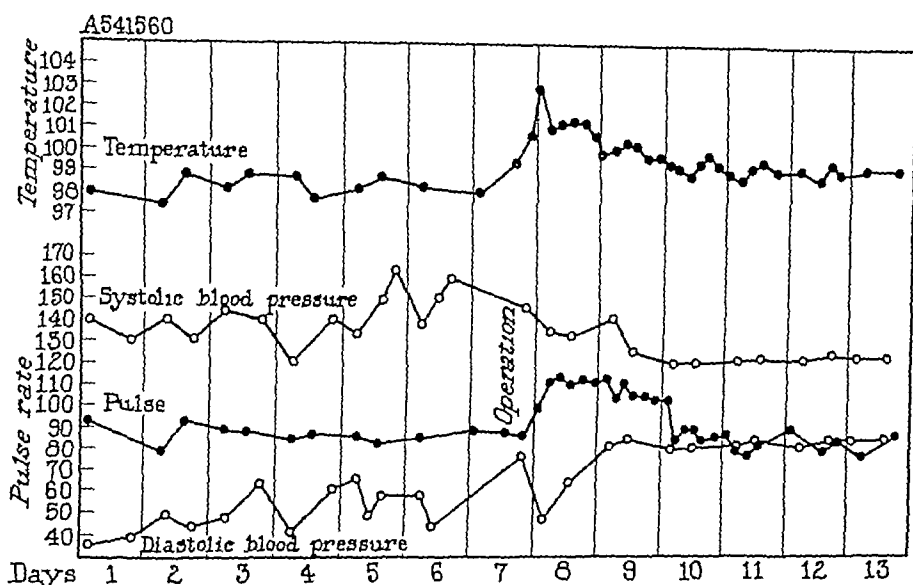


Fig 6 (case 16)—Bedside chart showing the striking effect of the operation on the blood pressure

was exposed extraperitoneally and tape was placed around it for control The artery was 3 or 4 cm in diameter, being four or five times larger than normal, and the vein was hugely dilated, probably two or three times larger than the artery, marked thrills were felt A vertical incision was then made over the thigh, perpendicular to the first, running over the anterior surface of the thigh, about 12 or 15 cm below the level of Poupart's ligament The femoral vessels were exposed The superficial veins were markedly dilated and bled profusely when opened The femoral artery below the anastomosis was small, about one-fourth the size of the external iliac A direct communication between the artery and the vein could not be made out because of the excessive amount of scar tissue I finally tore into the artery and ligated it, and then removed a segment of the artery and vein, including the origin of the profunda femoris The segments of the artery and the vein were probably 7 or 8 cm in length Both ends of the artery and vein were tied with heavy fish-line silk The operation was extremely difficult on account of the situation In order to secure exposure it was necessary to cut Poupart's ligament This was later resutured Lymph nodes in the

2 **Immediate Survey of the Case** An immediate survey is made by some one of sufficient experience to size up the case quickly and accurately and to order the appropriate treatment. Patients in a state of shock are not unduly exposed and complete examinations and the taking of roentgenograms are delayed until there is sufficient recovery. When there is bleeding from the ears, speculum examinations are postponed and are performed only under aseptic conditions.

3 **Immediate Surgical Treatment** Surgical treatment is usually necessary only in cases of superficial hemorrhage or lacerations of the scalp. If the patient is in a severe state of shock, all extensive procedures are delayed, heat applied and dextrose administered intravenously or subcutaneously. The strictest asepsis is maintained, and after the wound has been thoroughly cleaned, it is probed with sterile instruments or gloves. The closure of a wound can usually be accomplished without drainage unless it is very much contaminated. Moribund patients should be absolutely quiet, heat being applied and stimulants, etc., used.

4 **Tetanus Antitoxin** Tetanus antitoxin (1,500 units for adults) is given in all cases in which a real wound may have been contaminated with dirt. The possibility of anaphylaxis must be borne in mind.

*Roentgen-Ray Examination*—If the patient's condition warrants it, the next step is to take roentgenograms of the skull. Enough are made to give details of the type and location of the damage. Sometimes one or two are sufficient. Basal fractures require a special technic. The roentgenograms are read at once. If the fracture line crosses the middle meningeal groove, hemorrhage can be expected, if it is depressed or enters an infected sinus, early surgical intervention may be necessary.

*Medical Treatment (Conservative)*—All patients should be hospitalized for a varying length of time, depending on the severity of the injury. Our outline of procedure is

1 If the patient is in a state of shock, the head is kept low, heat is applied to the body and a 5 per cent solution of dextrose is injected by rectum (1,000 cc) or intravenously (500 cc) if urgent. Ice is applied to the head, and caffeine is given when necessary.

2 After recovery from the shock, the head is raised and kept up to combat edema. The pulse rate, respirations and blood pressure in serious cases are taken every fifteen minutes for four hours, then the interval is increased to every four hours as the conditions warrant. The nurses are instructed to take the blood pressures, their results are checked at intervals by the interne.

3 A neurologic examination is made when the patient is admitted to the hospital, in serious cases, the results are checked at frequent intervals in order to note early signs of a rapidly progressive lesion. The nurses are instructed regarding the danger signals and should know the

to the silk suture. The patient's general condition was good and the pulse was normal. There was practically no swelling in the leg. The result was excellent.

After operation the patient weighed 53 Kg (117 pounds), and the hematocrit showed 34 per cent erythrocytes and 66 per cent plasma. The whole blood volume was 85 cc for each kilogram of body weight (normal 85), the total volume was 4,515 cc. The plasma volume was 56 cc for each kilogram of body weight, the total volume was 2,980 cc (figs 3 to 7 and table 1).

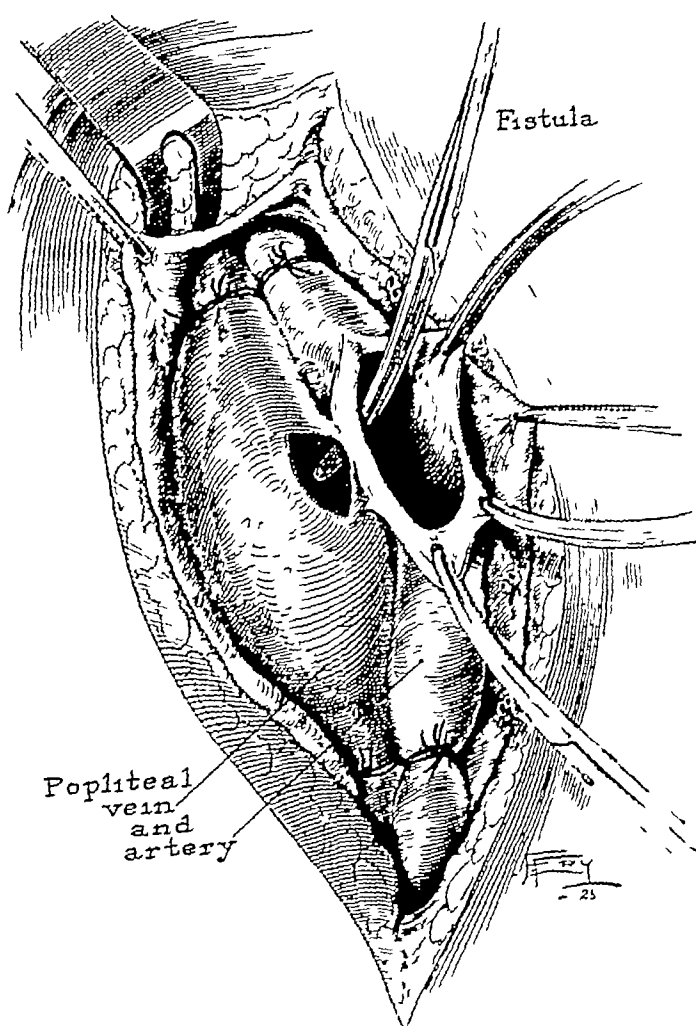


Fig 8 (case 15) —Traumatic arteriovenous aneurysm of the left superficial femoral artery and vein of twenty-six years' duration. Quadruple ligations preliminary to the excision of segments of artery and vein, including the fistulous tract.

CASE 2 (case 15, table 2) —*History*—A man, aged 39, came to the clinic on Nov. 17, 1919, complaining of varicose veins which had first appeared at the age of 15. He gave a history of a gunshot injury at the age of 13, at which time a 22-caliber rifle bullet entered the left thigh. Enlargement of the veins of the left leg appeared one year later and arteriovenous aneurysm one year after this. Operation was performed when he was 18, and part of the veins were removed, however, they soon reappeared. The aneurysm had grown larger gradually,

fluid. This was possibly so in some of our earlier cases, in which a large number of punctures became necessary in order to control the increasing pressure. The Queckenstedt maneuvers may be dangerous in cases of injury of the head, and are not usually indicated.

6. Another valuable means of nonsurgical reduction of intracranial pressure is the use of hypertonic solutions. In our experience, dextrose and saline have proved the most satisfactory, and dextrose has the advantage in that it is less likely to be injurious, furnishes nourishment as well and is more prolonged in its effect. We use dextrose alone or combined with 15 per cent saline, 25 per cent (from 100 to 200 cc) or 50 per cent (from 50 to 100 cc) is slowly injected intravenously, insulin being added if necessary. If the case is less urgent, magnesium sulphate is given, 2 ounces (59.2 cc) by mouth or 3 ounces (87 cc) by rectum. Hyper-

TABLE 6—*Method of Treatment with Results*

	Operation		No Operation			
			Medical Treatment		Not Treated	
	Survived	Died	Survived	Died	Survived (Transferred)	Died (At Once)
Early operation	3	13				
Late operation	5	1	363	29	5	23
Total	8	14				
Operations, total		22	Total, no operation (medical)	392	Total no operation (transferred) (died)	28
Percentage of patients operated on		43	Percentage medical treatment to total	88.8	Percentage no treatment to total	6.4
Mortality rate of patients operated on		59.1				
Operative mortality rate of total cases in series		32	Mortality rate (medical)	6.6	Mortality rate (not treated)	5.2
Total number deaths whole series		60	Total mortality rate of whole series			11.7

tonics do not seem to have any appreciable effect on hemorrhage or laceration, but they clear up the edema temporarily. The treatment may have to be repeated from every six to eight hours. Care must be exercised that dehydration does not result from overdoing the procedure. The intake and output of fluids are carefully charted and the balance regulated according to the conditions.

*Surgical Intervention*—As already stated there is still a difference of opinion regarding the indications for surgical intervention. Series of cases have been reported in which operations were performed on 70 per cent of the patients; in series recently reported operations were performed on from 30 to 10 per cent. In our series craniotomy was employed in only 4.3 per cent of the total number of cases (table 6). Subtemporal decompression was performed for middle meningeal hemorrhage and craniotomy elsewhere for definitely depressed fracture, debridement for compound fractures or penetrating wounds with contamination, drainage of abscess of the brain or a compound fracture man-

TABLE 2—*Acquired Arteriovenous Aneurysms* \*

Case	Age, Years	Sex	Cause	Lesion	Dura tation, Years	Cardiac Enlargement	Blood Pressure			Trophic Changes	Date of Operation	Type of Operation	Proximal Artery Dilated, Grade	Result	Comment and Subsequent History
							Sys- tole	Diastolic	Pulse						
1	29	♂	Bullet	Arteriovenous aneurysm of left popliteal vessels	11		70	134	82	Varicose veins and scars of previous operation	9/25/15	Endo aneurysmorrhaphy	—	?	Letter May, 1916 Sore on leg, numbness, thrill before bending leg, flexion impeded
2	49	♂	Lacerated wound	Arteriovenous aneurysm of right palmar arch	42		88	138	90	Gangrene of finger	5/29/16	Partial amputation of right hand		Well	
3	35	♂	Bullet	Arteriovenous aneurysm of left subclavian	9	Slight (roentgenogram)	64	120	66	Tremendous congestion	5/23/16	Obliteration of fistul ous tract by ligation	+	Well	Letter March, 1926 Slight swelling, strength all right, examination by home physician, con- dition satisfactory
4	60	♂	Blow	Cirsoid aneurysm of forehead	42		142		80		1/25/18	Ligation of vessels		Im- proved ?	
5	38	♂	Bullet	Arteriovenous aneurysm of left popliteal	1½		76	118	72	Tremendous congestion	6/ 6/18	Excision and ligation		Well	Letter March, 1926 well
6	46 (figs 9 to 12)	♂	Bullet	Arteriovenous aneurysm of right jugular carotid vessels	30	+	90	120	64		7/20/19	Ligation of communi- cating fistulous tract small sacular aneurysm of carotid artery oppo- site site of arterioven- ous fistula, neck ligated	2	Well	Died Dec 9, 1926, follow- ing operation else- where for cancer of the stomach
7	29	♂	Bullet	Arteriovenous aneurysm of left peroneal	15	?	88	140	75	Ulcers of left leg	6/27/19	Excision and ligation of artery and veins		Well	Letter May, 1926 well
8	11	♂	Bullet	Arteriovenous aneurysm of right popliteal vessels	14		62	134	60	Engorgement of veins of leg	9/27/19	Ligation with catgut of communication between artery and vein	4	Died	Secondary hemorrhage six days after opera- tion, second operation for excision of aneu- rysmal sac dry gan- grene of foot and lower leg rupture of right femoral artery result of injury from tourniquet necrosis huge dilatation of right common and ex- ternal iliac and right femoral arteries

an equally strict regimen. If headaches, vertigo or other unfavorable symptoms develop when the patient returns to work, a lumbar puncture may be indicated, and if the pressure is high, another period of rest is needed with a sufficient spinal drainage to return the pressure to normal. Administration of mild sedatives, such as phenobarbital may be necessary for nervousness or insomnia. One of the dangers in the cases is the development of neurotic fixations, particularly in certain types of compensation cases. Skilful handling is necessary to prevent this complication.

# RESULTS

In reviewing a large series of old cases, it is impossible to arrive at a reliable classification of results. Some patients left the hospital early against advice, many did not return for a follow-up and some doubtless

TABLE 7—Results

Cured		Recovered, But With Sequelae on Discharge										Not Treated		Died					
Temporary Dis- abilities While in Hospital	No Disabilities or Sequelae	Headache	Vertigo	Stiffness	Cranial Nerve Involvement	Fatigue General Disability	Nervousness	Psychoses	Epilepsy	Hemiplegia	Transferred to Another Hosp	Left Against Advice	Less than 6 Hrs	7 to 12 Hours	13 to 18 Hours	19 to 24 Hours	2 Days	3 Days	Over 4 Days
39	244	27	2	1	11	21	3	6	4	1	6	0	2	10	3	2	10	0	0
Totals 283		78										15		6					
Percentage of total series		17.7										3.4		14.7					
64.2																			

ligament to about 9 cm from the popliteal. For 10 or 12 cm above the knee immediately below the apex of Scarpa's triangle, the artery was more distended than elsewhere, and there seemed to be a constriction just above this. The artery was tightly adherent to the vein at the point of constriction, and it is possible that there was a communication between the artery and the vein at this point, although it could not be definitely made out. The artery was separated from the vein high in Scarpa's triangle and a tape placed around it to control bleeding. The artery was injured at this time and there was some bleeding which was easily controlled by digital pressure. Below this point the artery was separated from the vein above and below the constriction, near the site of the bullet wound, and a silk ligature was passed around the point of possible communication with the vein.

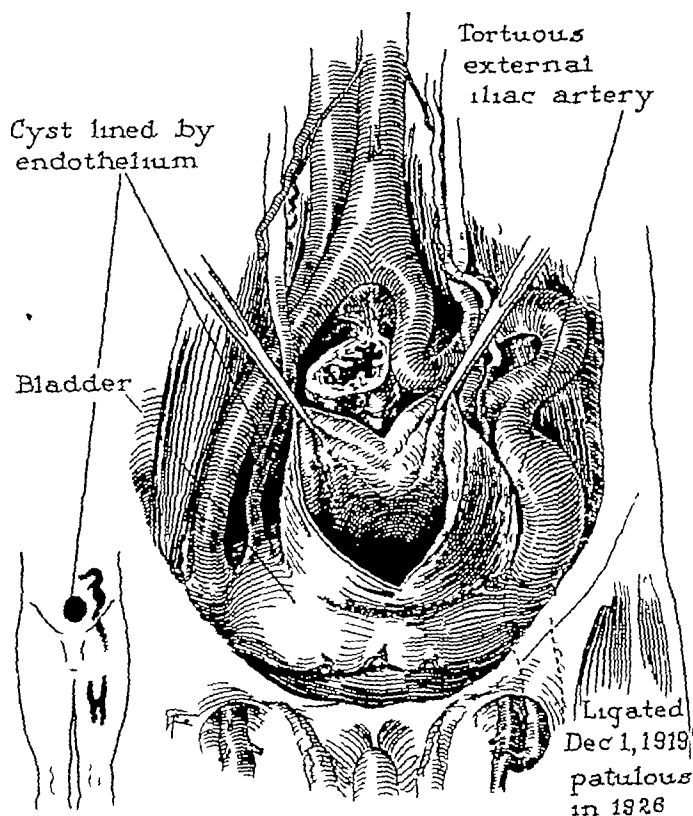


Fig 10 (case 15) —A large (from 15 to 20 cm in diameter) retroperitoneal cystic tumor lying slightly to the left of the median line and above the bladder, lined by endothelium and containing old, partly clotted blood was first discovered during the convalescent period after the excision of the fistula. The origin or the exact nature of the cyst could not be determined, but any connection with the iliac arteries was definitely excluded.

This, of course, produced further constriction of the artery. A definite purring thrill could not be felt in the vein before this ligation, but afterward there was less impulse. On removal of the tape, there was considerable bleeding from the artery, which could not be controlled other than by ligating the femoral artery just below Poupart's ligament and above the deep profunda artery. After the ligation there was a definite pulsation in the distal artery (dilatation of about 3 cm in diameter) which showed that the collateral circulation was well established.

For comparison, we have tabulated some of the data from other series which were suitable for comparison (table 9). The complications in our cases while in the hospital are shown in table 10. No doubt some cases of meningitis were prevented by prophylactic means such as early drainage of frontal sinuses, debridement in compound fractures and aseptic treatment of the ears and nose and other parts. Harvey<sup>27</sup> reported remarkably good results with his serious cases by rigid adherence to aseptic principles.

Our cases of meningitis were all fatal in spite of every effort. Only the future will show whether or not we can develop a method of treatment to cure some of these patients. More radical early irrigation with specific serums and antiseptics seems to offer some hope.

The results of injuries of the head in children are somewhat more favorable. They seem to show fewer sequelae and have a greater per-

TABLE 10—Complications

	Meningitis	Hemiplegia	Cranial Nerves	Hemorrhage	Abscess of the Brain	General Pneumonia Embolism	Cardiac Failure	Hernia Cerebri
Recovered in hospital		9	Third 1 Fifth 1 Seventh 2 Eighth 1 Sixth 1					
Discharged with disability		1	Fifth 1 Sixth 1 Seventh 4 Eighth 5	7	1	1		1
Died	4	5	Fifth 1	2				
Totals	4	15	22	2	1	4		1

centage of recovery. They are, however, more apt to develop later sequelae such as epilepsy, spasticities, developmental retardations and other conditions. In 1927, Moorhead<sup>28</sup> reported 109 cases with a mortality rate of 26 per cent or 17 per cent if associated injuries were excluded.

# PROGNOSIS

Prognosis should be guarded until at least six months or a year have passed. This is particularly true in children and in cases in which insurance and compensation are involved. In our experience even simple injuries may be seriously impaired later by organic or functional damage. The return of the function of involvements of the cranial nerves is sometimes slow and distressing.

27 Harvey, Samuel C. Compound Cranial-Cerebral Injuries. *Ann. Surg.* 23:911 (Dec. 6) 1923.

28 Moorhead, J. J. and Weller, Walter. Fracture of the Skull. *Ann. Surg.* 74:72 (Dec.) 1921.



pulsation was noted in the distal end of the femoral artery after the completion of the operation, showing that the collateral circulation was well established. A segment of the artery and vein, including the arteriovenous fistula about 4 or 5 cm in diameter, was removed. The wound was only partially closed and packed with gauze soaked in mercurochrome-220 soluble. It was necessary to give a transfusion of 500 cc of blood while the patient was on the operating table. The patient's condition was good when he left the table. A similar transfusion

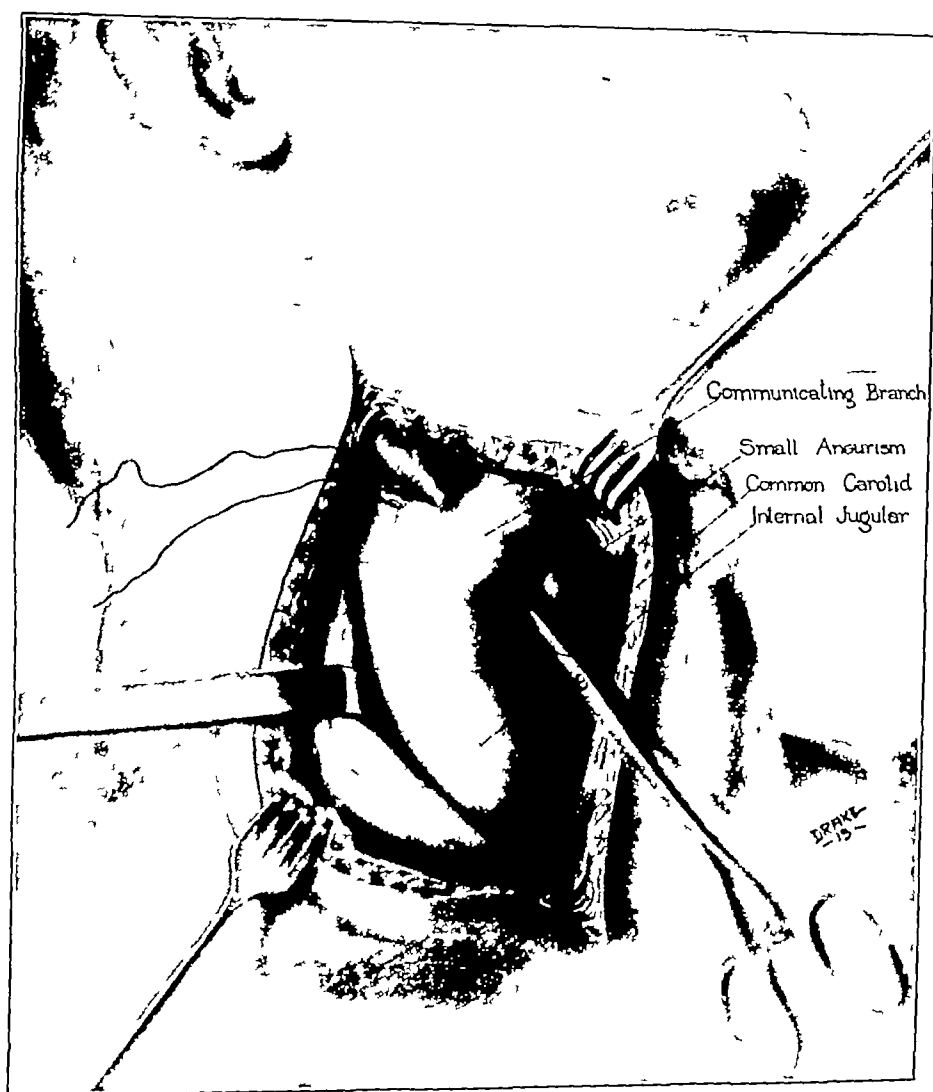


Fig 12 (case 6) —Dissection exposing the enormously dilated internal jugular vein, the common carotid artery, and isolation of the communicating branch

was given in the afternoon of the day of the operation. The pathologic report was arteriovenous aneurysm, with arteriovenous fistula about 5 mm in diameter.

On November 8, there was an indefinite mass over the left Poupart ligament, which felt expansile. On November 11, the mass was more definite and expansile. On November 13, the wound was resutured. The varicose ulcers of the leg healed with remarkable rapidity following the operation. The wound was dressed with a solution of chlorinated soda (Dakin's solution, 1:15). A solution of full strength was applied daily with a swab to the base of the ulcers. On

## ARTERIOVENOUS ANEURYSM\*

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In this discussion the term "arteriovenous aneurysm" is used to denote "any abnormal communication established between the arterial and venous channels" and includes, therefore, all direct and indirect communications variously spoken of as arteriovenous varix, varicose aneurysm, aneurysm by anastomosis, pulsating venous aneurysm and cirroid aneurysm. These communications usually result from trauma to the vessels, such as piercing, incisive, lacerating, crushing or contusive wounds (cirroid aneurysm of scalp is a notable example) and are known as acquired arteriovenous aneurysms, not infrequently they are produced by developmental anomalies, and are then termed congenital. The symptoms and systemic effects of the two types are essentially similar, the chief differences will be noted later.

In the Mayo Clinic from January, 1915, to April, 1926, operation was performed in forty-one cases of arterial and arteriovenous aneurysm. Twenty-five of these were arteriovenous, sixteen were acquired and nine were congenital.

In 1757, John Hunter first recognized and described the symptoms of arteriovenous fistula, and in 1920, Callander,<sup>1</sup> in an interesting report of a comprehensive study of the literature, recorded 447 cases, of which only three were congenital. While knowledge of the symptoms has been sufficient to enable one to diagnose the condition readily and while operative technic has been developed so that accessible fistulas can be operated on successfully, surprisingly little was known of the pathologic physiology until five or six years ago. Not infrequently the dilatation of the artery proximal to the fistula and evidences of cardiac injury were observed, but the causal relationship between these observations and the fistula was not appreciated. For present knowledge credit is given especially to the studies of Matas,<sup>2</sup> Makins,<sup>3</sup> Halstead, Reid,<sup>4</sup> Holman,<sup>5</sup> Hoover and Beams,<sup>6</sup> and Lewis and Drury.<sup>7</sup>

\* From the Division of Surgery, Mayo Clinic.

\* Read before the Pacific Northwest Medical Association, Boise, Idaho, June 1927.

1 Callander, C. L. Study of Arteriovenous Fistula with a review of 447 Cases, Johns Hopkins Hosp. Rep. **19** 260 (1920).

2 Matas, Rudolph. Testing the Efficiency of the Collateral Circulation Preliminary to the Occlusion of the Great Surgical Arteries. I. A. M. **63** 1834 (Oct. 24) 1914. On the Systemic or Cardiovascular Effects of Arteriovenous Fistula. Tr. South Surg. & Gynec. Assn. **36** 623 (1923).

3 Makins, G. H. Gunshot Injuries to the Blood Vessels. New York, William Wood and Company, 1916.

isolated and a tape put around it in order to control the bleeding in case the mass should be connected with the vessel. The mass was cystic, but not expansile, it was opened, and old disintegrated blood clots were removed. Fresh bleeding did not occur. The cavity was thoroughly inspected, and there was not any evidence of an artery opening into it. Bleeding did not occur after pressure was released on the external iliac. A segment of the sac was removed, and the pathologist reported that it was lined with endothelium with some muscle in its wall. After this, the interior of the sac was reexamined with the idea of finding some communication with an artery, but this could not be demonstrated. The cavity was packed with a long double strip of iodoform gauze. It was first thought best to leave a tape around the external iliac in order to control bleeding if there should be secondary bleeding, but as the tape did not slip well, indicating difficulty in removing it later, it was decided to remove the tape. One Penrose drain was left outside of this. It would have been impossible to obliterate the sac by suture. The pathologic report was old hemorrhage and fibrin in the wall of an artery.



Fig 14 (case 6) —Nine days after operation. Patient lived for seven years in good health without any evidence of recurrence of aneurysm, when he died following an operation elsewhere for cancer of the stomach.

For about six days after the operation, the patient's temperature was 102 F and the pulse rate, 110, there was much cough and sputum. The gauze was shortened on the twelfth day after operation and taken out on the seventeenth day. A Penrose drain was inserted into the drainage sinus and kept in for several days. On the forty-first day, the patient was dismissed from the hospital with the wound healed, he was able to walk well with the use of a cane. On March 2, the systolic blood pressure was 102, the diastolic, 64, and on March 8, the systolic was 98, and the diastolic, 66. The result was excellent (figs 8, 9 and 10).

This case illustrates several points of special interest. The ligature around the fistulous tract failed to close the arteriovenous communication permanently. In this instance, the tract was not definitely isolated and extravascular fibrous tissue was no doubt included in the tie, this probably accounted for the subsequent loosening of the ligature and the reestablishment of the fistula. At the time of the operation, Feb 8, 1926

*Systemic Symptoms*—Systemic changes are not present in all cases of arteriovenous aneurysm their presence or absence, as clearly pointed out by Holman, is dependent on two factors the size of the fistula and the unobstructed return flow to the heart. The larger the opening and the longer it exists, the more likely the development of cardio-vascular changes. Holman's explanation of the hydraulics of the flow of blood in cases of arteriovenous fistula based on intensive clinical and experimental studies, is convincing. With the production of an arteriovenous fistula there are two systems of circulating blood the normal from heart to artery to capillary bed to veins and the abnormal from heart to artery to fistula to vein. As the fistula offers considerable less resistance to the circulation of the blood than the capillary bed a large volume of blood will be directed through this fistula the amount varying with the size of the fistula. Only a relatively small volume of blood will escape through a small fistula, and there will not be an appreciable change in the size of the vessels. If the opening is large however a greater volume of blood will flow toward and through it. The proximal artery and vein dilate to provide for this increased volume of circulatory fluid. As Holman has pointed out, "this dilatation is progressive and will continue until the resistance offered by the fistula plus the resistance to any further dilatation of the vessels leading to it equals the resistance which exists in the capillary bed elsewhere. The proximal artery becomes enormously dilated and in places in which the artery is not firmly supported in a bed of muscles or fascia the artery also is weakened as evidenced by its great tortuosity. I had an opportunity to expose the external iliac arteries in two cases of femoral arteriovenous aneurysm and in both this bending and twisting was so marked that a 25 per cent increase in length could be estimated. The streaming of this large volume of blood through the fistula increases the local pressure which causes the heart to fill more quickly with a consequent increase in the force and the rate of action and ultimate hypertrophy and dilatation of the heart. This diversion of a large volume of blood from the normal system is followed by an immediate fall of general blood pressure. In order to maintain the blood pressure at a level comparable to normal there must be an increase in the total volume of circulating blood. Drury believed that the enlargement of the heart in cases of arteriovenous fistula is due to dilatation and not to hypertrophy. The fall of blood pressure and the consequent fall of blood pressure due to the marked lowering of the aortic pressure is not compensated by any increase in the venous pressure in the venous system. The work of the heart was not increased and the heart was not hypertrophied after the establishment of an arteriovenous fistula.

# FOREIGN BODIES IN THE STOMACH

REPORT OF A CASE IN WHICH MORE THAN TWO THOUSAND  
FIVE HUNDRED FOREIGN BODIES WERE FOUND \*

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AND

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To find foreign bodies in the stomach is by no means rare, in fact, the medical literature is so replete with reported cases that one hesitates to add another unless it is of unusual interest

Many of the patients are children who pick up objects and swallow them accidentally or intentionally. In the normal adult the presence of foreign bodies in the stomach is usually the result of the accidental swallowing of articles held in the mouth, although at times one sees people, otherwise normal, who have the habit of swallowing hair and other objects. This habit may be accentuated in some insane patients, and it is from this group that the strangest and largest number of objects have been recovered at operation, or more often at autopsy

## REPORT OF A CASE

The following case, we feel, qualifies for a place in literature

Mrs H, aged 42, had been a patient in the Ontario Hospital for a year and a half on account of manic-depressive insanity. Suicidal tendencies were present, and sometimes she would pick up and swallow various foreign bodies. In May, 1926, a roentgen-ray examination (S G C) revealed several of these (bent safety pins, wire and buttons) at different levels of her gastro-intestinal tract. They were not causing symptoms, and appeared to be passing through the intestine without difficulty, for a roentgenogram taken a month later showed an entirely different collection of articles. She improved somewhat mentally, became less melancholic and was not observed to be swallowing things, therefore it was thought that occupational therapy might be of further benefit, and she was allowed to go to the sewing room. Her general health improved, but at times she was seen to swallow objects. On May 20, 1927, she complained of slight abdominal pain, and a movable mass, about 4 inches (10 cm) in diameter was palpable below and to the left of the umbilicus. On roentgen-ray examination,

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the femoral vessels this dilatation extended up as far as the common iliac vessels. The proximal artery was dilated in nine of the sixteen cases of acquired aneurysm, it was normal in two, and the condition was not recorded in five. Dilatation was noted in three of the nine cases of congenital aneurysm. The frequent finding of calcareous plaques and the ease with which the vessels are ruptured indicate that the walls of the arteries are often degenerated as well as dilated. In case 8 a right popliteal arteriovenous aneurysm of fourteen years' duration and rupture of the right superficial femoral artery followed the application of a tourniquet. In case 15, a left femoral arteriovenous fistula of twenty-six years' duration, a large mass (from 15 to 20 cm. in diameter) developed in the left pelvis, and exploration revealed a retroperitoneal cystic mass nonpulsating and containing old partially clotted blood. The examination of the wall of the mass showed the structure of an arterial wall but a direct communication with the iliac artery could not be demonstrated. The degenerative process obviously results from the tremendous dilatation of the artery, which in turn prevents adequate nutrition of its wall by partially obstructing the vasa vasorum. The veins in the vicinity of the lesion are markedly dilated, also, and in cases of congenital lesions the walls of the veins are thickened, or arteriolized, in many instances it is difficult to differentiate the artery from the vein.

#### DIAGNOSIS

The diagnosis of arteriovenous aneurysm should not offer any difficulties. The characteristic bruit and thrill, continuous throughout the cardiac cycle with systolic intensifications, and the transmission proximally and distally along the line of the companion vein and its tributaries alone should make the diagnosis almost certain. An absolute diagnosis can be made if an analysis of the blood taken from one of the veins in the immediate vicinity of the lesion is found to be rich in oxygen.

#### PROGNOSIS

Although instances are reported in the literature of the spontaneous healing of recently acquired (within two or three months) arteriovenous aneurysms, it is extremely unlikely that any arteriovenous fistula of three or four months' duration will heal without surgical intervention. It is much more likely that the lesion will remain chronic and that the symptoms will progress steadily with enlargement of the fistulous tract. The ultimate prognosis of any untreated arteriovenous fistula will depend on the size of the fistulous opening, the most influential factor in the production of cardiovascular injury. Reid reported that Osler followed two cases of arteriovenous aneurysm (one in the femoral and one in the femoral) in which death occurred from cardiac disease within a few

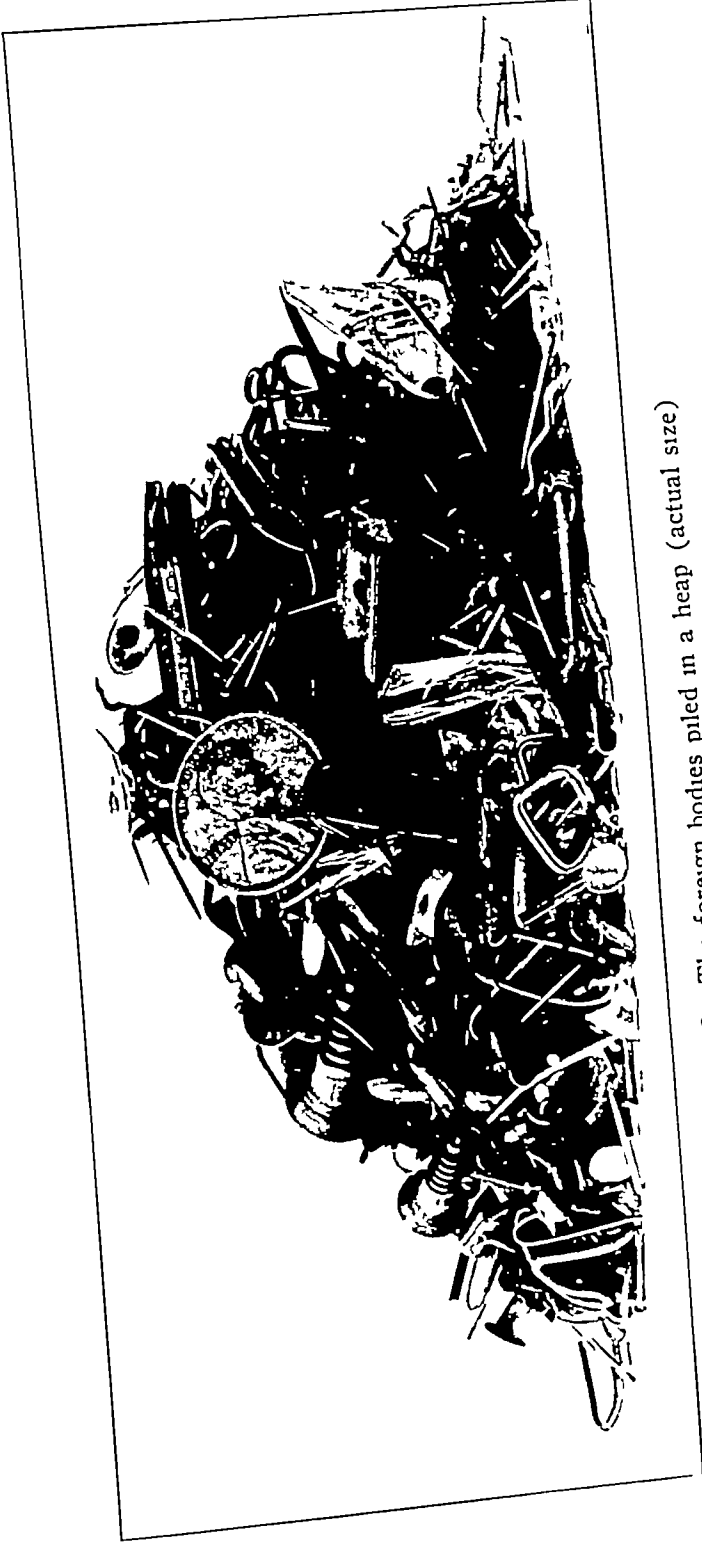


Fig 2 —The foreign bodies piled in a heap (actual size)





individual pieces. The case also illustrates the number of unsuccessful attempts at suicide. It is true that the patient took care, in most instances, to bend the pins and wire and even to bend the points of a pen nib, but this was probably to facilitate swallowing rather than to protect herself. It is remarkable that there should have been so little evidence of injury to the gastro-intestinal tract, for there were many straight, pointed

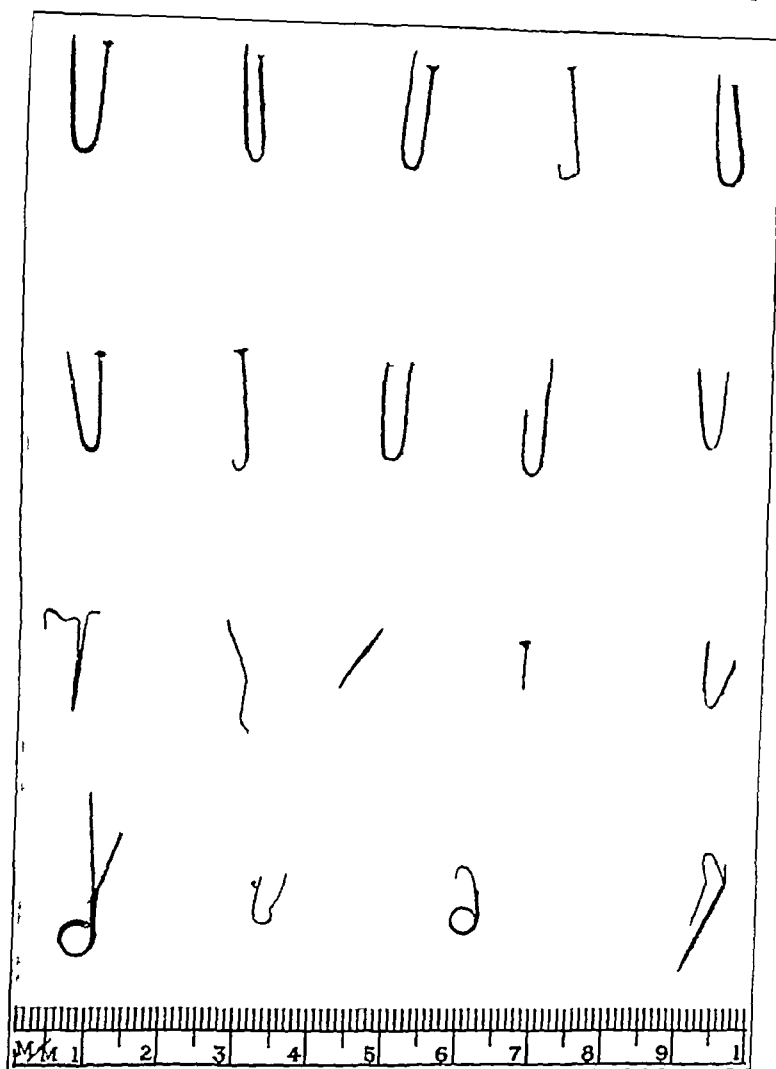


Fig 4—Illustrating corrosion of pins and safety pins

and angular articles which could easily have damaged the mucous membrane. This patient is still swallowing objects. Unless she was placed in solitary confinement under close constant individual observation it would be impossible to prevent this entirely, and it would not be practical in this case. By reasonable care, however, it is hoped that the number of articles ingested may be small, so that they may have a chance to pass through the gastro-intestinal tract individually.

efficiently maintained. In case the artery alone is ligated, the blood supplied by the arterial collaterals finds a too ready exit through the unobstructed vein. By ligating the vein also, the blood pressure in the distal parts is actually increased. This has been substantiated by ample experimental and clinical observations. Recently, Holman and Beam have shown by experiments on the dog that the blood pressure in an extremity in which the main artery has been ligated will be materially elevated if the satellite vein is obstructed at a corresponding site, and, if the obstruction is made at a point proximal to the ligature on the artery so as to include the important venous tributaries, the pressure will be raised to an even higher level.

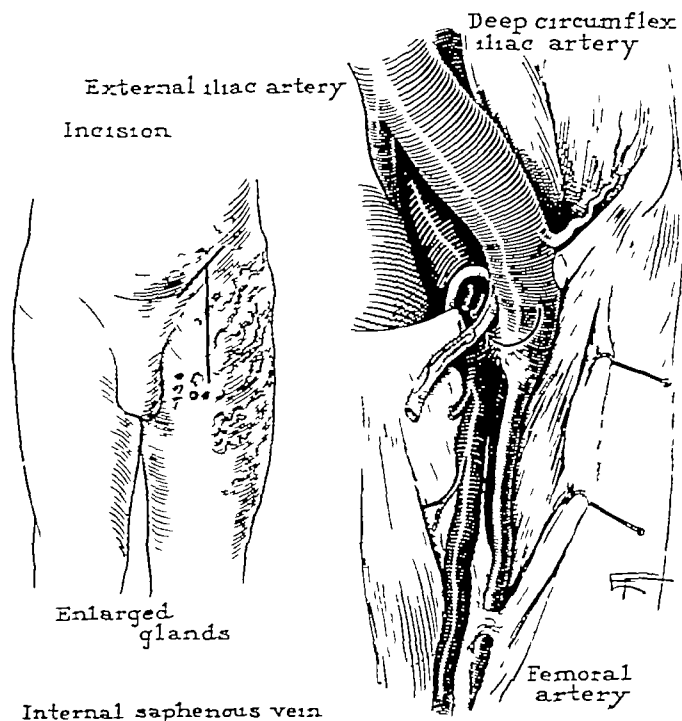


Fig 4 (case 16) —Arteriovenous aneurysm. The arrow indicates the position of the fistula. The enormous dilatation of the proximal artery and vein with diminution of the size of the distal artery were noted at operation.

#### REPORT OF CASES OF ACQUIRED ARTERIOVENOUS ANEURYSM

CASE 1 (case 16, table 2) —*History*—A man, aged 19, was admitted to the Mayo Clinic, Feb 22, 1926, complaining of a swelling in the left leg, so severe that his local physician had advised him to wear an elastic stocking. About six years previously, he had been accidentally wounded with a 22-caliber rifle. The bullet entered the anterior medial surface of the left thigh, about 13 cm below the inguinal ligament. The bullet was not removed. There was considerable hemorrhage at the time of the accident and the patient fainted. He said that he felt a thrill in the upper part of the thigh before leaving the hospital, the thrill increased progressively. In a few months he noticed that the left thigh and leg were larger than the right, also that the veins in the left leg had become distended. Three years later he injured the anterior surface of the left leg and an ulcer appeared that did not heal.

In 1927, Blackburne<sup>9</sup> reported the removal of a "mass of safety pins" weighing 295 Gm. Roentgenograms were shown, but an actual count was not given.

The article of greatest weight removed by gastrotomy seems to be that reported by Swain,<sup>10</sup> in 1895, namely, a hairball weighing 5 pounds and 3 ounces. As far as we know, our patient enjoys the doubtful honor of having had the largest number of objects ever reported removed from any stomach either surgically or at autopsy.

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9 Blackburne, George. Mass of Safety Pins in the Stomach, *J. A. M. A.* 89:1059 (Sept. 24) 1927.

10 Swain, W. P. Case of Gastrotomy. Removal of a Mass of Hair Weighing 5 lbs. 3 oz. from the Stomach—Recovery, *Lancet* 1:1581, 1895.

marked in the thigh. All veins of the left leg were distended. The blood pressure with the fistula open was 142 systolic and 40 diastolic, and with the fistula closed, 164 systolic and 80 diastolic. There were partly healed ulcers on the anteromesial surface of the left leg. Two roentgenograms were taken, one of the chest which showed the heart to be enlarged 2, the other of the left hip which showed a large fragment of lead over the head of the femur with small particles over the neck

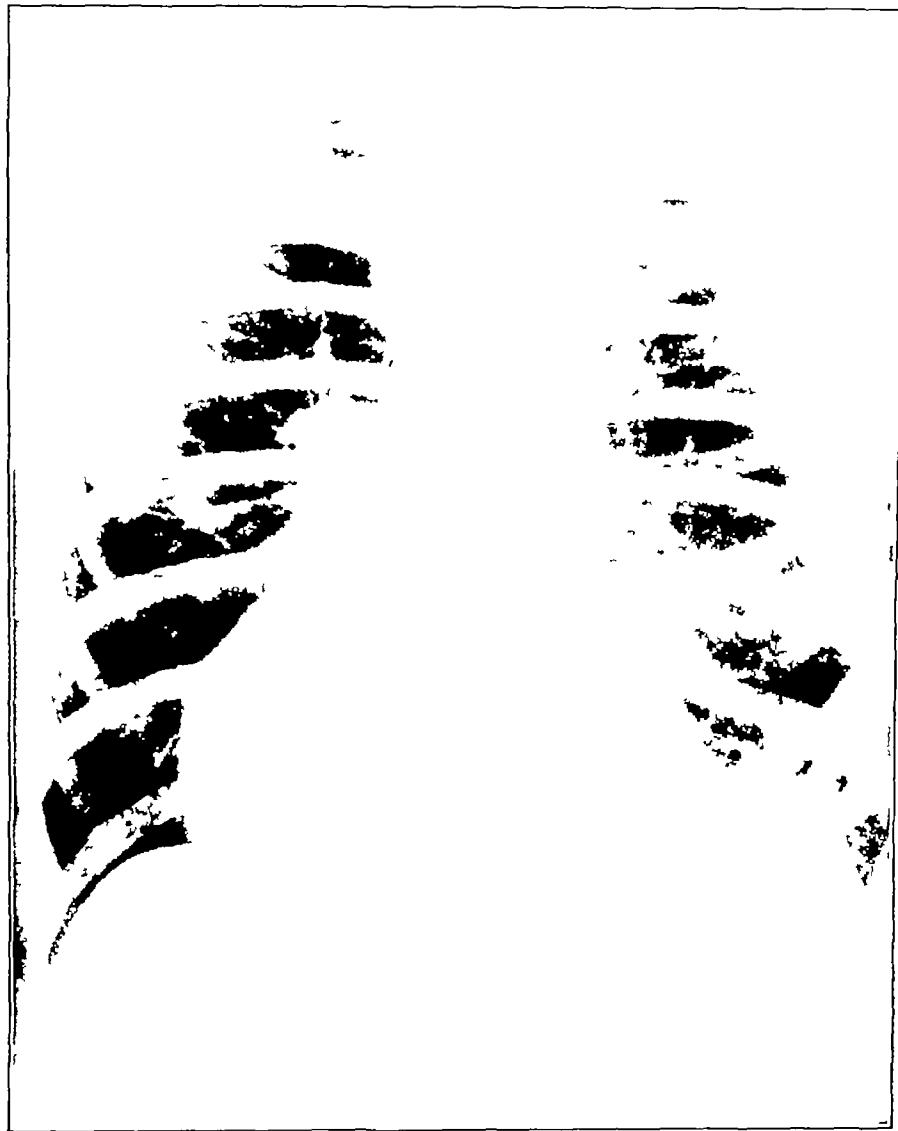


Fig 5B

and inner aspect above the trochanter. The electrocardiographic report showed a pulse rate of 86, sinus rhythm, aberrant ventricular complex in isolated derivation I, and slurred right ventricular preponderance. The systolic blood pressure was 150, and the diastolic was 60. The hematocrit showed that the plasma was 65 per cent and the erythrocytes, 35 per cent. The oxygen capacity was 23.2 per cent, and the oxygen content, 18.2 per cent, making an oxygen saturation of 78 per cent. The carbon dioxide combining power was 66 per cent by

lung It should only be used to indicate the condition in which "a lung or a lobe of it is completely deprived of its air contents" The expression "partial collapse" is misleading and should be replaced by "partial deflation" "Partial deflation of pulmonary bases," as it is used for bedridden patients, signifies the loss of efficient inspiratory force It has little or nothing in common with true collapse, either clinically or anatomically, but it is doubtless predisposing to "patchy collapse" of the lung

"Massive collapse" differs from "patchy collapse," according to Pasteur, both in its mode of origin and its clinical features It is probably always determined by a grave failure of inspiratory power, and may be distinguished from patchy collapse in cases in which there is paralysis of respiratory muscles (diaphragm, intercostal and other muscles) by its sudden supervention without any premonitory signs of respiratory paralysis The former variety apparently is always unilateral and includes all cases of postoperative collapse

In order to avoid the confusion arising from the use of the word "massive collapse," Scott proposes the term active collapse or active atelectasis in order to distinguish it from passive collapse or passive atelectasis, which is due to the compression of the lung by pneumothorax, the effusion of fluid in the pleura, or even to a tumor

Jackson and Lee prefer the term "atelectasis" to "collapse" because the latter suggests the simultaneous collapse of alveolar tissue and bronchi as it occurs in all cases of increased and positive intrapleural pressure, whereas in the so-called acute postoperative massive collapse of the lung, collapse of the bronchi does not take place So far as "partial collapse" or "partial deflation" is concerned, Jackson and Lee consider it a common condition in the lung after death, being a lesser degree of postoperative collapse, and for that reason they do not consider it worth while to create a special terminology, thus unnecessarily increasing the already existing confusion of terms We suggest that the term "atelectasis" always be used instead of "collapse," because, as will be seen, collapse can occur without atelectasis, but atelectasis can never occur without collapse Even "atelectasis" is a misnomer, and "apneumatoxis" should be used in its stead The most appropriate name for the condition is "obstructive massive apneumatoxis of the lung"

We believe that the definition as well as the etiology and mechanism of this condition of the lung will be much simplified if the conclusions of our experimental work are true We firmly believe that there are only two kinds of "collapse" or atelectasis of the lung, one is due to obstruction of a bronchus, and the other to compression of the lung, the first is active, the second is passive If we substitute for the

inguinal region were greatly enlarged and it was necessary to remove some of these in order to obtain exposure. The internal saphenous vein was ligated, and the external iliac was doubly ligated just above Poupart's ligament. The deep circumflex iliac and the deep epigastric arteries were also ligated. Two Penrose drains were inserted, one in each wound. Convalescence was normal. On the third day after the operation the pulse was dicrotic. The size of the heart was diminished.

On March 7, the right thigh measured 42 cm, and the left, 48 cm, the right calf measured 29 cm, and the left, 31 cm. The systolic blood pressure was 120,



Fig 7 (case 16) —Thirty-one days after operation for excision of fistula. A letter from the patient in January, 1927, stated that his general condition was excellent.

the diastolic, 80. On March 21, the right thigh measured 42.5 cm, the left 45 cm, the right calf measured 28 cm, and the left, 31 cm. On April 3, the systolic blood pressure was 115, the diastolic, 80. The heart was reduced in size, there were no murmurs and the action was regular. On April 19, the patient was dismissed. Both wounds in the operative field and the ulcers were healed. Above the left Poupart ligament the tissues beneath the skin were indurated, and formed an irregular mass probably from 8 to 10 cm in diameter. This induration could be felt with the finger in the rectum. There was no soreness at the point of induration and no pulsation, the induration was attributed

Gairdner, in 1851, admitted that the most frequent cause of collapse is bronchitis, in this condition, the bronchi are obstructed with mucus, which acts as a ball-valve going down and blocking the funnel-like bronchus during inspiration, upward displacement during expiration allows exit of air from the bronchioles, and thus the air is gradually emptied from the obstructed portion of the lung. But this explanation, although simple, presupposes a perfect functioning of the ball-valve, even then the complete disappearance of the air in the affected portion of the lung cannot be explained. Notwithstanding the multiple objections to this theory, it met with real success at that time and Rilliet and Barthez admitted it.

Barthels, in 1860, in a great number of autopsies first demonstrated mucous secretion in the bronchi corresponding to the atelectatic portion of the lung, and later attracted attention to atelectasis of the bases, often symmetric, following bronchial diphtheria. "Diphtheria of the bronchi," he said, "is regularly followed by atelectasis of the portions of the lung corresponding to the obstructed air passages." He tried to explain the collapse by the obstacle presented to the inspiratory entrance of air into the alveoli by swelling of the mucosa and by a spastic contraction of the bronchial muscles due to inflammatory irritation of the bronchial mucosa. Air does not enter because of the resisting forces opposing its entrance, namely, the strong expiratory and cough movements. But this theory did not satisfy even Barthels, who added in his paper: "It does not seem quite satisfactory to admit that this mechanical expression of the alveolar air alone can produce collapse of lung tissue. Another factor must intervene here, especially the air absorbing capacity of the blood circulating in the capillaries encircling the alveoli, to which point Virchow first attracted attention."

The first author to study thoroughly the mechanism of massive "collapse" seems to be Jurgensen. In studying the symmetric collapse of the lowest and posterior segments of the lung, he arrived at the conclusion that it was due to incomplete respiration in those regions in which even normally the respiration is not active, therefore, in the corresponding bronchi there is an easy accumulation of mucus, which finally obstructs them. This obstruction is facilitated by the decrease of respiratory movements and cough. *Once the obstruction is established, the air contained in the alveoli is rapidly absorbed by the blood circulating in the capillaries.* This absorption is facilitated by the pressure exerted on the enclosed air by the elastic walls of the alveoli and by the surrounding lung.

Lichtheim, in 1879, published a paper which even now is the most remarkable experimental piece of work on the mechanism of "collapse." By a great number of well conducted experiments on rabbits, in which he obstructed the bronchi with sticks of laminaria, he demonstrated

and there was some edema of the leg. An ulcer just above the ankle had existed since he was 15, this had gradually increased in size.

*Examination*—An aneurysmal mass in the middle third of the thigh posteriorly, and a large ulcer of the left leg were present. The systolic blood pressure was 115, the diastolic, 65. There was a systolic murmur to the left and over the precordium, the heart was enlarged to the left and downward, and the pulmonic second sound was accentuated. Over the left femoral artery was a to-and-fro systolic murmur and a bruit was transmitted upward and downward from the aneurysm. No anterior or posterior tibial pulse was felt. The results of urinalysis were negative, except for pus cells, grade 4. The combined phenolsulphon-

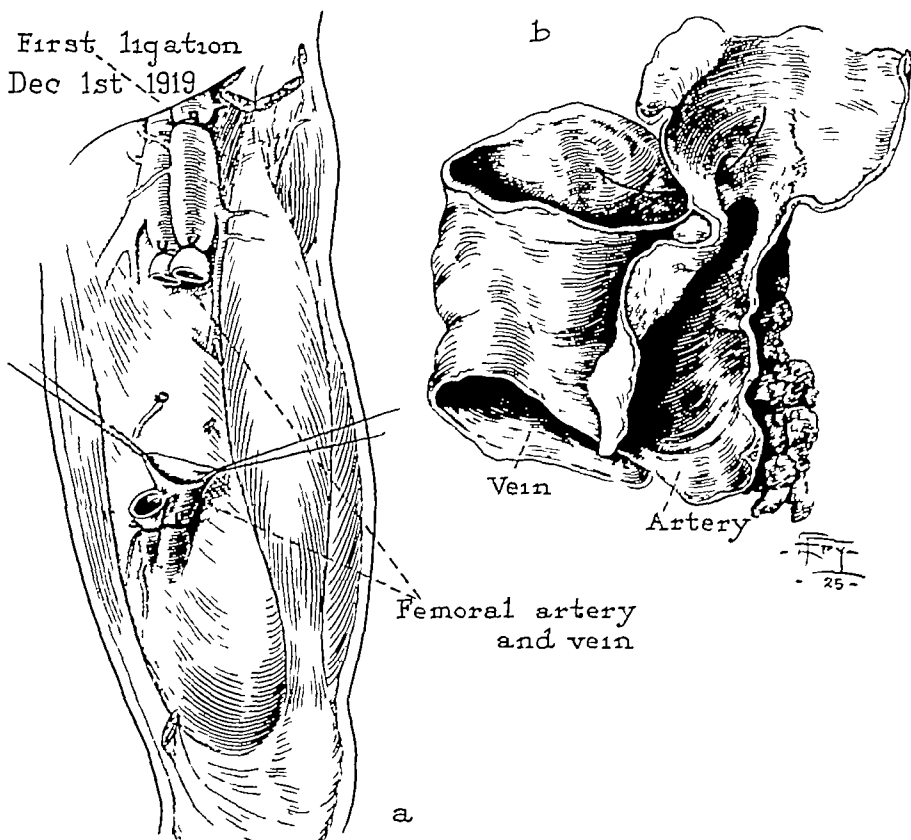


Fig 9 (case 15)—Excision of segments of the superficial artery and vein, including the fistula. Six years previously the first part of the left femoral artery and of the fistulous tract had been ligated with heavy silk with temporary improvement. Circulation was subsequently reestablished at site of both ligatures and was followed by the development of a deep and exceedingly foul smelling trophic sore of the leg. Immediately after excision of the fistula marked improvement in the circulation of the foot and leg with rapid healing of the ulcer was noted.

phthalein test was 20 per cent in two hours. The blood urea was 16 mg per hundred cubic centimeters. Roentgenogram of the kidneys, ureters and bladder was normal. Cystoscopic examination revealed a stricture of the bulbous urethra.

*Operation and Course*—Operation was performed on Dec 1, 1919. There was a large fusiform dilatation of the entire femoral artery from beneath Poupart's



technic was perfected, we were able to produce the condition at will, and thus study the details of mechanism, evolution, complications and the methods of treatment

#### ETIOLOGY AND MECHANISM

The opinions held for the explanation of the production of collapse of the lung can be summarized as follows

- 1 Compression of the lung due to paralysis of the corresponding diaphragm
- 2 Inhibitory respiratory reflex
- 3 Reflex spastic contraction of the bronchial muscle.
- 4 Obstruction of the bronchus due to angioneurotic edema of the mucosa of the bronchi
- 5 Mechanical expulsion of the air through an incompletely obstructing plug of mucus acting as a ball-valve
- 6 Complete obstruction of a bronchus through a plug of mucus (or a foreign body), and absorption of the alveolar air by the blood circulating in the capillaries

Before entering into the discussion of the mechanism and etiology, we shall mention a few important and well known physiologic facts

1 The intrapulmonary pressure is equal to one atmosphere with slight variation during inspiration and expiration, the air passages being free

2 The intrathoracic or intrapleural pressure and pressure in the mediastinal spaces is always negative and less than an atmosphere by an amount equal to the elastic recoil of the lungs. In other words, the negative intrapleural pressure is equal to the elastic recoil of the lungs and corresponds to about 4.5 mm of mercury at the end of expiration and 7.5 at the end of inspiration, according to the figures given by Heynsius. This was proved by Hermann, who showed that the fetal and the new-born child's pleural cavity up to the third or fourth day do not show a measurable negative pressure, owing to the fact that the elasticity of the lung has not yet come into play. It follows that although the new-born child has practically no reserve supply of air in the lung, and that at each expiration the lungs are entirely emptied, a small amount of air, the minimal air, always remains in the alveoli. But, as Howell remarks, "if for any reason the alveolar ducts or respiratory bronchioles were blocked for any length of time by mucus, for example, the air captured in the atria and air spaces might be absorbed partly or completely, giving a condition of local consolidation."

3 Each gas of the air ( $N_2$ ,  $O_2$ ,  $CO_2$ ) in accordance with the mechanical laws of gas pressure in a mixture of gases, exerts a pressure corresponding to the proportion of that gas present. Thus, in the air, oxygen being present to the extent of 20 per cent exerts a pressure of one fifth of an atmosphere, or  $\frac{1}{5} \times 760 = 152$  mm of mercury

9	21	♂	Bullet	Arteriovenous varix between right carotid and internal jugular veins	6 (roentgenogram)	72	152	58	12/3/19	Ligation of communicating branch, small sacular knob (aneurysm) 2.5 cm on anterior surface of internal carotid at site of fistula, neck ligated	3+	Well	Last report two years ago	
10	21	♂	Bullet	Arteriovenous aneurysm of right axillary vessels	%	80	120	70	5/ 6/20	Tremendous congestion of arms	+	Well	Brachial plexus involved in aneurysmal mass and accounted for atrophy of hand and forearm, last report December, 1921	
11	31	♂	Bullet	Arteriovenous aneurysm of left femoral vessels	2½	Marked	92	140	50	2/ 2/21	Ligation of communicating fistula	3+	Improved	Slight thrill and bruit, but condition improved 90 per cent under periodic observation
12	30	♀	Puncture wound with scissors	Arteriovenous aneurysm of right posterior tibial	20	70	108	70	4/21/21	Varicose veins of legs, scars of previous operation	—	Well	Letter, May, 1920, "Wonderful success of operation"	
13	18	♂	Blow to jaw	Aneurysm of right facial artery and vein	2	—	72	115	78	8/ 8/21	Excision and ligation	—	Well	Letter, March, 1923
14	10	♂	Contusion from fall	Circoid aneurysm of scalp frontal region	24	—	88	132	88	8/27/21	Ligation of temporal arteries and excision of aneurysm	2	Well	Last report, January, 1925
15	30	♂	Bullet	Arteriovenous aneurysm of left femoral artery at apex of Scarpa's triangle	25	+	115	65	12/1/19	Deep ulcer on leg	2	Improved	Worked as cook until readmission, November, 1925	
16	10	♂	Bullet	Arteriovenous aneurysm of left femoral just beneath Poupart's ligament	6	+ Extra systole	70	122	00	11/4/25	Excision and ligation of femoral arteries and veins	3	Well	Pelvic mass 15 to 20 cm in diameter, slightly to left of midline discovered during convalescence from second operation, cystic clinically, questionable, expansile pulsation, encysted hematoma, origin questionable, recent report condition very good
16	19	♂	Bullet	Arteriovenous aneurysm of left femoral just beneath Poupart's ligament	6	Dilatation 2+	90	161	80	3/ 1/26	Excision and ligation	2+	Well	Letter from patient January, 1927 general condition excellent, slight serous drainage from abdominal wound

\* Pemberton, J. de I. and Sabat, J. H. Communicant arteriovenous communications, Surg., Gynec. & Obst. (in press)  
 † In this table ♂ indicates male, ♀, female

causes a narrowing of the bronchi and therefore increases the resistance to the inflow and outflow of air. Drugs known to stimulate the endings of bulbar autonomic nerve fibers, such as muscarine, pilocarpine and other preparations, seem to increase the tonus of the bronchial muscles, as well as does irritation of the nasal mucus membrane. Atropine, epinephrine, extracts of lobelia and nicotine have the contrary effect, and abolish the constriction when it exists. The last fact is important, because in a case of atelectasis, as we shall see later, atropine in high dosage was given hypodermically without causing any improvement.

These few physiologic notions will permit us more readily to attack the problems of etiology and mechanism of apneumotosis of the lung. The existing theories may be divided into three classes. The first does not admit complete mechanical obstruction of a bronchus as a necessary and indispensable condition for the production of the condition. Under this heading would come a more or less effective narrowing of the lumen of the bronchioli through spastic contraction of the muscular ring, inhibitory respiratory reflex and compression of the lungs due to paralysis of the diaphragm or the respiratory muscles. The second theory is that a mechanical valve-like obstruction allows exit but not entrance of air into the bronchus. The third theory, on the contrary, is that atelectasis is not possible without complete obstruction of a bronchus. The last is our belief and the conclusion we arrived at after long experimental study.

The exact knowledge of the mechanism of production and the etiology of massive atelectasis is not only of theoretical value. There is no doubt that "collapse," massive or patchy, constitutes one of the most frequent postoperative complications of the lung, being far more frequent than lobar pneumonia. Pasteur, Rose-Bradford, Cutler, Jackson and their associates, and almost all the modern authors agree on this point. Pasteur says "Indeed I would go so far as to say that when physical signs, especially at the right base suggest pneumonia, the odds are in favor of massive collapse." It is admitted, furthermore, as probable that "collapse" favors the development of infectious complications of the lung by microbes coming from the outside or by the fixation in the "collapsed" areas of small septic emboli coming from the operative wound, which, without collapse would not cause any noticeable trouble.

Accurate knowledge of the etiology and mechanism of atelectasis of the lung, therefore, is of great interest to the surgeon, because it would enable him to prevent the occurrence of this condition or to treat the patient efficiently.

The theory advanced by Pasteur, *i. e.*, that massive "collapse" is due to paralysis of the diaphragm, in our opinion, cannot be admitted today as a sufficient cause. Pasteur reports sixty-four cases of postdiphtheritic

At operation on December 24, Thiersch's skin graft was applied to the ulcerated area of the left leg. Convalescence was uneventful. The patient was dismissed on Feb 11, 1920, with wound healed, except for a varicose ulcer.

*Second Admission to the Hospital*—The patient returned on Oct 28, 1925, with a history of having been more or less incapacitated since the operation in 1919. He did not work for a year and a half after the operation and then worked as a cook in a construction camp for about two years. During the last summer, his left leg had given more trouble than before the operation.

On admission there was a deep malodorous sloughing sore above the left ankle, and the foot was bluish and cool. There was fusiform dilatation of the left femoral artery which extended from the left external iliac, 5 cm above Poupart's ligament to the popliteal region. Thrills and bruits were present throughout most of this area and there were many varicose veins and much scarring. The knee could not be completely extended. The results of urinalysis were negative, except for pus, grade 4. The hemoglobin content was 74 per cent, the erythrocytes



Fig 11 (case 6) —Traumatic arteriovenous aneurysm of the right jugular carotid vessels of thirty years' duration

numbered 4350,000 and the leukocytes, 12,900. The blood Wassermann test was negative. The phenolsulphonphthalein return was 50 per cent. The blood urea was 16 mg per hundred cubic centimeters. A roentgenogram of the chest was negative. The same cardiac conditions were manifest, but there were occasional extrasystoles. The systolic blood pressure was 122, and the diastolic, 60.

*Second Operation*—On April 11, an incision was made in the scar of the old incision. There were a great many adhesions between the artery and the muscles, so many that it was difficult to free the artery above this point, and profuse bleeding from the collateral veins was encountered, the blood being arterial in character. This was controlled with great difficulty, but I finally succeeded in putting a tie of heavy silk around the vessel above this point, including both the artery and the vein. This did not check the bleeding, and it was necessary to break up the adhesions hastily and place a mass tie around both the artery and the femoral vein below the aneurysm. This stopped the bleeding. The artery was then laid open, disclosing a small fistula about 1 cm in diameter between the artery and the vein, and enormous dilatation of the vein. The femoral artery and vein were ligated en masse and separately above and below the aneurysm. Good

This is mentioned in only two cases in case 10, in which the bronchi were empty, and in case 2, in which there existed "a general dilatation of the bronchi which exuded pus on pressure" He also quotes a case of Samuel West in which there was "collapse" following plastic bronchitis The report made at autopsy reads "An extensive collapse of the left lung developed consequent to obstruction of the main bronchus by a cast"

Paralysis of the diaphragm alone does not seem to produce great disturbance in the respiratory mechanism The great majority of authors have not noted atelectasis of the same lung when phrenicotomy has been performed for tuberculosis (Sauerbruch) or in experimental sections of one or both diaphragmatic nerves in the neck in animals Lemon, in his recent paper on the physiologic effects of phrenic neurectomy, stated that he sectioned one or both phrenic nerves and did not find atelectasis of the lungs either during life or at autopsy He noticed congestion, but not atelectasis, only in a dog on which he performed double phrenicotomy "In examination of animals," he said, "several weeks after phrenic neurectomy it was impossible to determine with exactness the side that had been operated upon when only physical examination and tambour readings were available" In the roentgen-ray examination, the heart of this dog was found in its normal position, and alteration of the normal density of the lung could not be observed Changes did not occur in the intrapleural pressure on the operated side or in the functional respiratory capacity of the animals before and after phrenicotomy Sections of the lung did not show any change So far as the movements of the thoracic wall are concerned, Lemon said that they are not influenced by phrenicotomy in either extent or direction

In order to check up Pasteur's theory, Elliot and Dingley performed phrenicotomies on cats and rabbits They did not notice any pulmonary changes In other cats they performed hemisection of the spinal cord at the second and third cervical segments, respectively, complete paralysis of the intercostal muscles and the diaphragm of one side followed After three days, the animals were killed, "collapse" was not found in any case

Crymble reported a case (case 15) in which a complete paralysis of the diaphragm and respiratory muscles of the same side occurred as a consequence of a traumatism caused by a shrapnel ball at the height of the fifth cervical vertebra (direction of the shrapnel from the fifth to the third cervical vertebra) Atelectasis did not occur A great number of phrenicotomies have been performed for tuberculosis during recent years So far as we know, atelectasis of the lung has not been reported to date We find in the literature, however, a number of cases in which paralysis of the diaphragm was followed by massive atelectasis

November 16, the mass was smaller and not expansile. On December 26, the ulcers of the left leg were healed. On Jan 2, 1926, the patient's general condition was excellent, however, there was a hard and fixed mass 10 by 12 cm in the pelvis to the left of the median line. The mass could not be felt by rectum. There was no expansile pulsation. A dilated femoral artery, and probably also an iliac artery, could be felt above and below Poupart's ligament with marked pulsation. Below Poupart's ligament there was a hard mass extending into the groin. The upper part of the mass was pulsating. The appearance of the leg

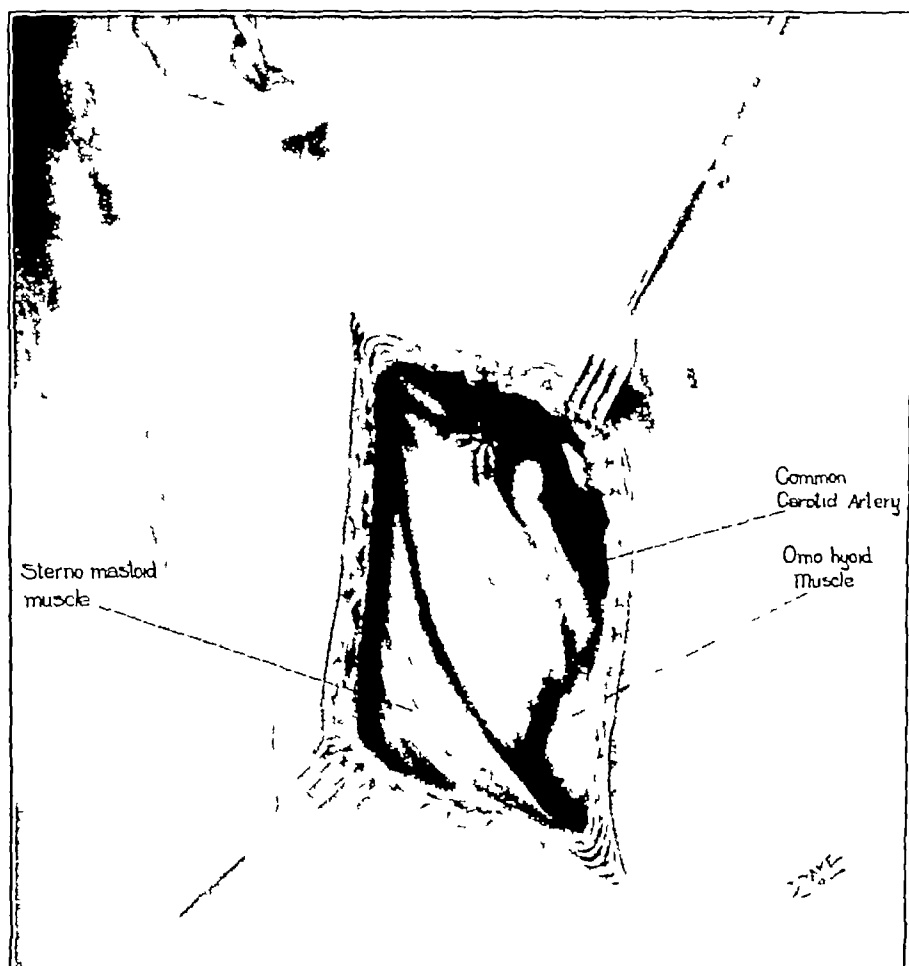


Fig 13 (case 6) —Collapse of the internal jugular vein after ligation of the communicating branch

was satisfactory. The mass suggested an aneurysmal condition with clotting. Exploration was advised.

*Third Operation*—Operation was performed on February 8 through a low incision in the median line. There was a postperitoneal mass arising from the left pelvic wall, probably about 20 cm in diameter. The wall of the mass was about 0.25 cm thick. The mass did not seem to be attached to any vessel although the left external iliac ran behind to its external surface. The first impression was that of an aneurysm from this artery which was hugely distended, probably between 3.5 and 5 cm in diameter and extremely tortuous. The vessel was first

of patchy "collapse" We quote the opinions of Bradford extensively because they have gained considerable recognition in most papers written concerning massive "collapse"

In opposition to the opinions expressed by Thoenes, Wallgren and other authors that the condition is due to compression by emphysema of the other lung, Rose-Bradford does not concede the existence of such a condition of the other lung, although he admits it in patchy "collapse" complicating bronchitis He does not believe that spastic contraction of the bronchial muscles can produce atelectasis, because "never in asthma cases, in which this condition exists, does massive collapse occur"

It is evident that the theory of paralysis of the diaphragm and of other respiratory muscles cannot alone explain the production of atelectasis We have repeated the experiments of Lemon on dogs, and our results agree with his We have never been able to produce atelectasis by unilateral or bilateral phrenicotomy Jackson, Lee, Scott, Tucker and others showed that in diphtheria the obstruction of bronchi by membranes often produces atelectasis Systematic and routine aspiration of these membranes by bronchoscopy gave Jackson and his associates remarkable results in the ward for patients with diphtheria in the Municipal Hospital in Philadelphia "This post-diphtheritic collapse described by Pasteur," said Jackson, "is really due to bronchial obstruction of the air passages by diphtheria exudates and by the routine removal of these exudates we have been able to prevent it"

In our opinion, the sequence of phenomena would be obstruction of a bronchus, absorption of the alveolar air, shrinkage and decrease of the volume of the lobe supplied by the obstructed bronchus As a consequence of the negative intrapleural pressure, there is flattening of the wall of the chest, overdistention of the other lung, displacement of the heart and mediastinum toward the affected side and elevation of the diaphragm, which is "sucked" into the thoracic cavity of the same side Thus the ascension of the diaphragm would not be the cause but the result of atelectasis Even in cases of undoubted paralysis of the diaphragm this is only an indirect cause, and by the slowing-down of respiration in the lower lobes, it favors the accumulation of secretions in the corresponding bronchi Other indirect causes are limitation of thoracic movements, prolonged recumbency and diminished cough ("the watch-dog of the lungs," as Jackson calls it) Cough is inhibited because of pain from traumatism (even superficial) of the thoracic wall, operations on the abdomen (more especially those on the upper part) and lesions of the abdominal cavity This theory explains the rarity of atelectasis in lesions, operations or wounds of the lower extremities and its total absence in operations on the head or upper limbs This explanation not only sounds simple and logical but has its basis in "col-

when compression of the external iliac artery stilled the femoral artery, it was definitely proved that the pulse of the femoral artery was a continuation of the pulse of the external iliac and was not due to collateral circulation. The reestablishment of the lumen of one of the larger vessels after ligation has been noted previously. A mass formed in the pelvis. While a definite communication with the external iliac or femoral artery could not be determined, it unquestionably developed from an artery. It may have been of spontaneous origin, but I am inclined to believe that it resulted from the injury to the femoral artery in 1919, when it was found necessary to ligate it just below Poupart's ligament. The circulation of the left leg and foot was immediately improved after the destruction of the fistula. This was evidenced by the remarkably quick healing of the sloughing ulcer of the leg.



bronchial tree is free and "if artificial respiration is carried out the inflation and deflation of the lungs occur with not the least hindrance" (Coca) As would be expected, atelectasis of the lung has never been found in this animal

The objection might be raised that the guinea-pig dies so quickly after the lethal injection that atelectasis cannot develop If so, the same objection should weaken the validity of the reflex theory applied in cases of sudden atelectasis in man, concerning which precisely the same theory—bronchial spasm or angioneurotic edema—has been proposed There is a stronger argument in what happens in protracted anaphylactic shock in the guinea-pig As Auer stated, even in sublethal shock the lungs are always at least partly inflated Hoover suggested that the inflation of the lung in the guinea-pig is due to edema of the mucosa and not to tetanic contraction of the bronchial muscles One may well wonder if Hoover is correct about the merit of the explanation that atelectasis in man is the result of "angioneurotic edema", this theory is upheld by Bergamini and Shepard to account for their two rapidly fatal cases Swelling of the mucosa without the presence of a plug of some kind is not sufficient to cause the condition, because, as we shall try to show later, a complete and absolute obstruction of the bronchus is indispensable for the production of massive atelectasis For the same reason, we cannot agree with the suggestion of Sante that "most probably some infection or insult to the region of the vagus supplied produces a reflex action on the bronchi permitting their temporary collapse, once approximated the walls of the bronchioles are held in opposition by cohesion, collapse of the lung rapidly following due to absorption of alveolar air by the circulating blood" Whatever the origin of the stimulus may be, the reflex must be transmitted through the fibers contained in the sympathetic and pneumogastric nerves and their respective centers We have already mentioned that atropine given subcutaneously abolishes the action of the bronchoconstrictors In the case of Scott, 275 mg were given within thirty minutes in three doses, while the patient was under fluoroscopic examination Modification in the condition of the lung or displacement of the heart was not noticed This fact shows clearly that when the atelectasis has set in, it is no longer under the influence of the reflex that may have induced it by favoring accumulation of mucus in a bronchus which finally became completely obstructed Our own experimental work clearly demonstrated to us that massive atelectasis cannot occur if the obstruction is not absolutely complete, or it will cease to exist when the obstruction ceases to be complete

It seems that in the present state of our knowledge concerning the etiology and mechanism of massive atelectasis, we must distinguish the

this mass was seen to consist of foreign bodies. On June 10 1927, a gastrotomy was performed (H O F) through an incision in the lower part of the left rectus. The stomach, which had been pulled down into the pelvis, was lifted through the abdominal incision, and the following objects were removed:

*Objects Removed from Patient's Stomach*

Bent pins	947	Washers	6
Pieces of bent wire	865	Dress hooks	5
Pieces of glass	191	Roller bearings	2
Parts of safety pins	176	Complete safety pins	2
Tacks	58	Nuts	2
Parts of corset steels	54	Broken key	1
Parts of garter fasteners	28	Sewing machine needle	1
Nails	20	Coin (American cent)	1
Buttons	17	Cuff link	1
Straight pins	9	Pen nib	1
Screws	8	Unclassified	130
Beads	8		
Total			2,533



Fig 1—Foreign bodies in the stomach

While most of the objects were well preserved, many of the pins, hair pins, safety pins and nails showed evidence of corrosion. The outer surface seemed harder or was protected by enamel or nickel plate, for the greatest action was on the central core making the objects appear tubular or grooved (fig 4 and ends of hair pins in fig 3). It is plain that this is mainly a chemical and not a mechanical effect.

The item "pieces of bent wire" consisted chiefly of broken hair pins, while under "unclassified" were included small metallic fragments, pieces of porcelain, small stones and other objects. The aggregate weighed 410 Gm and nearly filled a pint sealer. The majority of the articles were small, the largest being 4 cm in length. The wall of the stomach was thickened, and contracted well after the

parenchyma, consequently, the absorption of air does not take place simultaneously in the whole parenchyma of the portion that is becoming atelectatic

Andrews, in his experiments on the cardiorespiratory function following atelectasis of one lung by bronchial ligature, as well as Scrimgeur (quoted by Archibald in the discussion which followed the reading of Andrews' paper), found that after ligature of a bronchus the lung becomes definitely atelectatic within from twenty-four hours to three days after the operation, owing to complete absorption of air

Jackson, Lee, Tucker and others contributed greatly to the demonstration of the relation between obstruction of a bronchus and atelectasis of the corresponding portion of the lung. They have demonstrated repeatedly that atelectasis of the lung follows obstruction of the bronchus, and that the liberation of the obstructing foreign body from the bronchus is always followed by disappearance of atelectasis. Furthermore, this phenomenon is so common that in the bronchoscopic clinic of Chevalier Jackson, it is used by the radiologist, Dr. Manges "as a diagnostic sign of nonopaque foreign bodies or of plugs of secretion that are essentially foreign bodies." That the relation between the obstruction of a bronchus and atelectasis is clear is proved by the following quotation of Jackson's: "In a number of cases the foreign body has shifted, causing atelectasis in different lobes not simultaneously but in succession. It has been very interesting to have Dr. Manges tell us in a case of shifting foreign body, 'now the prune stone is causing obstructive atelectasis of the lower lobe', the next day, 'now it is causing obstructive atelectasis of the upper lobe', later, 'now it is causing obstructive emphysema of the upper lobe with obstructive atelectasis of the middle lobe'."

But there is a *sine qua non* condition for the production of atelectasis and this is that the obstruction must be complete. In partial obstruction allowing ingress and exit of air ("pass valve" idea of Jackson), nothing will happen. If ingress is allowed but exit checked ("check valve"), an emphysematous condition will occur, complete absorption of the air takes place if both ingress and exit are stopped ("stop valve"). The lung will present the structure and appearance of a fetal lung.

But can this absorption of the alveolar air by the circulating blood be demonstrated experimentally? Furthermore, is it possible to give experimental proof that it is the only explanation? In other words, is it demonstrable that there can be no other mechanism for the production of atelectasis than complete obstruction (temporary or not) of an airway of any size corresponding to the area of the affected lung?

The solution of the questions has been the aim of our experimental work. Before giving our results, we shall state what has been known about the subject from the time of Lichtheim's paper in 1879 (from

load was removed, the stomach resuming its normal position. The mucosa was covered with scattered whitish plaques, as if silver nitrate had been applied. There was no gross evidence of hemorrhage, ulceration or perforation, nor were any perigastric adhesions present. With the exception of the position of the incision, there was no variation in the usual technic of the surgical procedure. The patient made an uneventful recovery from the operation.

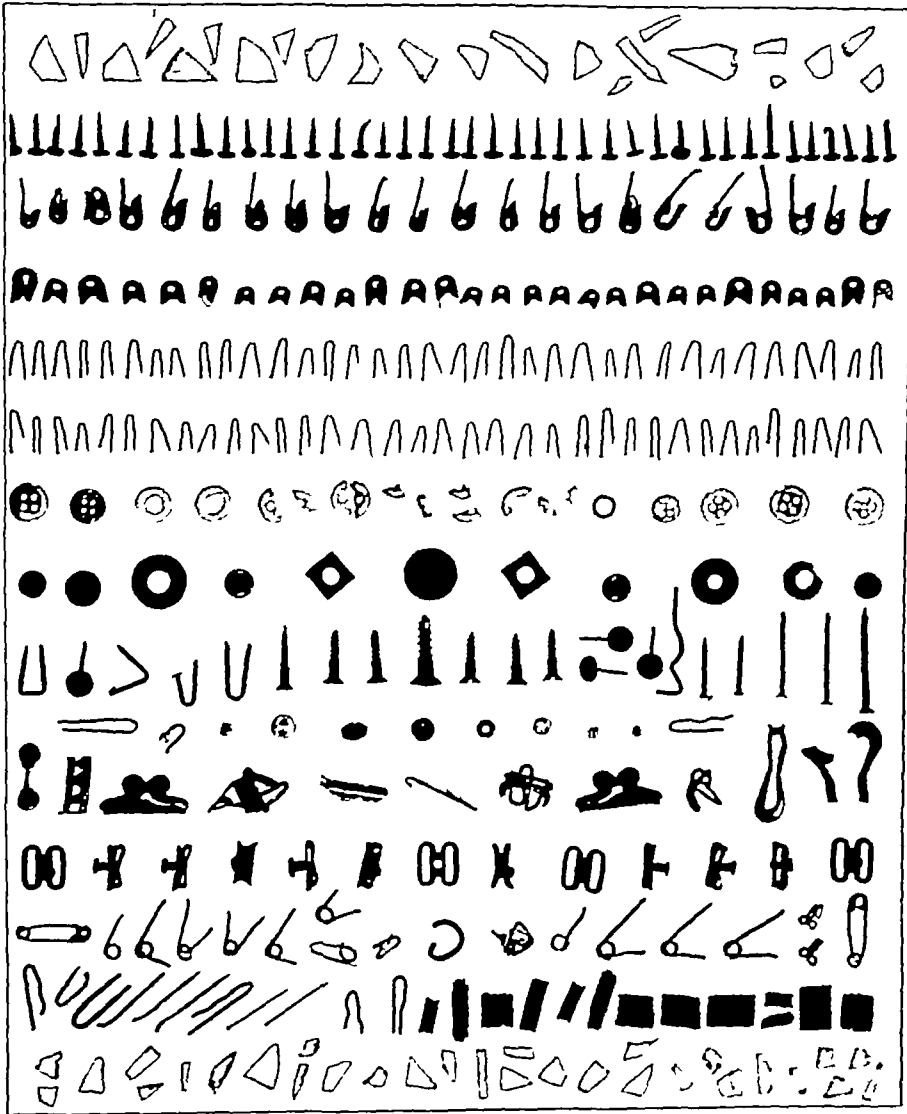


Fig 3—Some of the foreign bodies arranged to show greater detail (one-third actual size)

This case is of interest because of the large number and variety of objects removed at operation. The patient evidently could take care of a limited number, but over this optimum, they began to accumulate in the stomach because of the induced ptosis and the inability of the stomach to push the mass toward the pylorus and because of the interlocking of the

*2 Atelectasis Following the Obstruction of a Bronchus, with a Closed Thoracic Cavity*—The principles of absorption remain the same, but the explanation which may be true for the open thorax may not apply to the closed thorax. During the absorption of the air, the volume of the lung diminishes, because of the negative intrapleural pressure, the other lung expands gradually, and the mediastinum and the heart are displaced in order to fill up what may be pictured as the emptied space. In reality, there can be no such space. The contractility of the elastic tissue of the obstructed lung, however, will be opposed by (1) the stress and greater tendency to elastic recoil of the other (overdistended) lung and (2) the resultant pull on the mediastinal structures, the more the obstructed lung shrinks, the greater will these last two forces tend to become. What is the strength of these forces opposing collapse—forces which may diminish intra-alveolar pressure of gases and thus hinder their absorption? In order to calculate theoretically the alveolar pressure in the obstructed lung at a given moment, the value of the elastic overdistention of the other lung must be subtracted from the atmospheric pressure. Inversely, if even under these conditions total absorption of the alveolar air should occur, we should have to conclude that the elastic recoil of the obstructed lung is strong enough to counteract the resistance of the aforementioned opposing forces. Practically the pressure necessary to hyperdistend a lung is small and almost negligible, being equal to a fraction of a millimeter of mercury. The theoretical forces tending to lessen intra-alveolar pressure in the obstructed lung are thus also negligible and obviously cannot modify the intrapleural negative pressure.

The foregoing considerations hold equally well for patchy "collapse," which so frequently complicates bronchitis, and which is so often observed at autopsy, especially when the patient has undergone an abdominal operation. The only difference between patchy and massive atelectasis is in the size of the bronchus obstructed by a plug of mucus. Experimental as well as clinical observations leave no doubt about this point.

*3 Atelectasis with the Airways Free but with the Pleural Cavity Wide Open*—It is understood that this experimental work cannot be carried on, without intratracheal insufflation in dogs, in which complete permeability of the mediastinum would not allow the animal to survive even after only one pleural cavity was opened. Monkeys, calves or rabbits are more suitable animals for this study. We have said that even in these animals the lung becomes completely airless after a short time (from one to two hours in rabbits) when the chest remains open. Is this due to absorption by the circulating blood? We think there can be no doubt that it is. The proof is given by what happens after ligation of the pulmonary artery. As Lichtheim first showed, several

## REVIEW OF THE LITERATURE

In 1924, Thorek,<sup>1</sup> reported the case of a professional swallower from whose stomach he removed 276 articles besides a quantity of bits of glass and porcelain, he reviewed the literature up to that date. Gaylord<sup>2</sup> in 1903, removed 453 carpet tacks, 41 blades of small penknives, 142 screws, 40 pen-points, 6.5 ounces (184 Gm), of ground glass and a wire chain 3 inches (7 cm) long, the total weight being 2 pounds and 3 ounces (992 Gm).

In 1911, Vandivert and Mills,<sup>3</sup> while performing an autopsy on the body of an insane woman, found, 1,446 objects—453 nails, 42 screws, 9 bolts and 942 miscellaneous articles, including buttons, safety pins, hair-pins, carpet tacks and common pins—the total weight being 2,268 Gm. In this list they included 148 grape seeds and other smaller seeds, but counted a string of small beads 4 feet (121 cm) long as a single unit. In 1913, Matthews<sup>4</sup> removed 1,149 hair pins, nails and other objects, while Hoisholt reported that this patient was operated on again four years later, when 921 similar objects were removed. In 1919, Winslow removed from an insane patient nearly 1,300 articles, mostly small straight pins. The patient recovered from the surgical procedure. Curl and Culver,<sup>5</sup> in 1922, found 1,040 carpet tacks, 12 screws, 12 open safety pins and many small metallic pieces, the total weight being over 2 pounds (907 Gm). The patient made an uneventful recovery.

In 1924, Wardell<sup>7</sup> palpated a mass the size of two fists in the left lumbar region of a girl, aged 16, and later removed 2¼ pounds (1,020 Gm) of 1¼ inch (3.1 cm) nails, which had been swallowed over a period of nine years. In 1924, Tuft<sup>8</sup> had a patient who swallowed two packages of straight pins (about 500) and a few safety pins with suicidal intent. An operation was performed seven weeks later. A large perforation of the stomach with local peritonitis was found. The pins were removed, but the patient died in fifteen hours.

1 Thorek, M. Large Collection of Foreign Bodies in the Stomach. Report of Case with Review of Literature, *Internat Clin* **3** 282, 1924.

2 Gaylord, quoted by Friedenwald, J., and Rosenthal, L. J. A Statistical Report of Gastrotomies for Removal of Foreign Bodies from the Stomach. *New York M J* **78** 110, 1903.

3 Vandivert, A. H., and Mills, H. P. Foreign Material in the Stomach. Report of a Remarkable Case, *J A M A* **56** 180 (Jan 21) 1911.

4 Matthews, quoted by Thorek (footnote 1).

5 Winslow, R. Foreign Bodies in the Stomach. *Ann Surg* **70** 60, 1919.

6 Curl, H., and Culver, L. C. More than One Thousand Carpet Tacks in the Stomach, *J Radiol* **3** 489, 1922.

7 Wardell, W. H. Foreign Bodies in the Stomach. *Canad M A J* **14** 1105, 1924.

8 Tuft, L. Foreign Bodies in the Stomach, *M I & Record (supp)* **119** 30, 1924.

We thought it would be worth while to try to clear up this question by experimental work conducted with the aid of the bronchoscope and roentgen-ray control. Since the work of Lichtheim, we know of no systematic experimental research that has been made concerning this subject, despite the fact that he published his paper in 1879, long before the roentgen ray and bronchoscopy were known!

The problems we investigated are

1 Phrenicotomy unilateral and bilateral, study of the respiratory rhythm and the intrapleural pressure, obstruction of bronchi in phrenicotomized animals on the same and on the opposite side of the paralyzed diaphragm

2 Obstruction of a bronchus and investigation of atelectasis under direct observation, the animal being in a box with oscillating negative pressure

3 Obstruction of a bronchus with our obstructing elastic balloon and observation of the evolution of the "collapse" by fluoroscopy and serial roentgenograms. Autopsies have been performed and sections have been made on all our animals

#### GENERAL TECHNIC

Operations were performed under general anesthesia, which was administered by intraperitoneal injection of alkaline solution of iso-amyl-ethyl barbituric acid 10 per cent (10 Gm dissolved in 88.5 cc of half normal sodium hydroxide carbonate-free). This gave us an excellent anesthesia, the effects of which lasted from four to nine hours. The iso-amyl-ethyl barbituric acid does not influence the cardiorespiratory system, although large doses slow down the number of respirations. A few times we used ether in intratracheal anesthesia with the Connell apparatus.

The phrenicotomies were performed under strict asepsis. The phrenic nerve was found by an incision on the posterior border of the sternomastoid muscle, and avulsion was performed after section of every root or branch which seemed to have any connection with it. In this operation we followed the method described by Lemon. In making respiratory graphs on these animals, we used Lemon's method, slightly modified. Instead of using the stand constructed by this author and having the two pneumographs which were applied respectively to each part of the thorax of the animal and posteriorly and laterally on the frame of the stand, we fixed them directly on the animal. For that purpose, two small hooks were screwed posteriorly on the spinal process of the seventh or eighth thoracic vertebra and anteriorly on the middle of the sternum. Sometimes the pneumographs were fixed by a thread, instead of by hooks, to the integument posteriorly and anteriorly. This is a poorer procedure because of the mobility of the skin. We constructed special pneumographs, using sensitive coils of fine brass wire covered by fine rubber tissue. When connected with the tambours, the airtightness was checked up under water. The reason for the foregoing modification is that without it the animal can move independently of the pneumographs during the experiment. Even if this movement is slight, the change of position of the pneumographs on the wall of the chest is followed by changes in tension of the

# OBSTRUCTIVE MASSIVE ATELECTASIS OF THE LUNG\*

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Pasteur described postoperative atelectasis or collapse of the lung as a condition of this organ characterized by "the total deflation (as opposed to lobular or patchy collapse) of a large area of lung tissue, of sudden onset—in the absence of any signs of obstruction of the air ways or of any known source of compression—due to failure of inspiratory power and attended by definite physical symptoms and signs"

Since then, and even long before Pasteur had again brought it up as an actuality, many papers have been written on this puzzling condition. None seems to have given a definite solution to the etiology and the mechanism of it. In this paper, we propose to give the results of our experimental work conducted on fifty-six dogs. A careful study of the clinical symptoms, the physiologic phenomena, the roentgen-ray observations on serial pictures and the pathologic and bacteriologic condition of our animals convinced us that there is but one cause in the production of collapse of the lungs, and that is the more or less temporary, but complete, occlusion of a bronchus by a plug of mucus acting as a foreign body, and intercepting completely the penetration of air into the portion of lung depending on the occluded bronchus. Complete obstruction is an indispensable factor for the production of this syndrome. The other causes concerned in its etiology act only as predisposing factors, the only actual cause being, in our opinion, the complete occlusion of a bronchus. This conclusion is based not only on our experimental observations, but on the analysis of the history of the cases published, including those presented by Pasteur.

In order to facilitate the exposition of our subject we shall study successively in this paper the definition and value of the terms employed, the historic evolution, the etiology and mechanisms, roentgen-ray observations and the pathologic and bacteriologic processes of this condition. This paper is a general outline. A number of important points arising in the course of this work will be developed later in other papers.

## DEFINITION OF TERMS

As Pasteur remarked in 1913 much confusion has arisen from the careless use of the word "collapse" in relation to conditions of the

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is not necessary. In order to keep the mouth of the animal open, we constructed a special gag, using a rectangle of wood reinforced on the two sides with lead plate. The carina and then the main and secondary bronchi are located with the bronchoscope. When this has been done and the bronchoscope has been well fixed, the long glass tubing with the balloon attached is introduced. As the exact length of the system is known, one can easily calculate how far the balloon is from the tip of the bronchoscope, after a little experience, one can easily tell when the wire of the balloon has passed through the tip of the bronchoscope. The balloon is now inflated by injecting potassium bromide solution into it from the attached syringe. The amount varies greatly with the nature and size of the animal and with the form and size of the balloon. Generally from 5 to 7 cc are necessary for a balloon such as the one described and for a dog that weighs from 9 to 10 Kg. The syringe is now disconnected and a nonflexible iron rod (an ordinary piece of hay wire is suitable), 50 cm long and about 1 mm wide, is introduced through the glass tubing projecting from the proximal end of the bronchoscope down to the narrowed proximal end of the glass tube of the balloon, where it cannot go farther. The wire is firmly held at this point and the glass tubing is pulled gently in order to dislodge the balloon from the rest of the system. The balloon is now at the desired site and firmly held. The bronchoscope is removed, and the animal is ready for further observation.

This method of bronchial obstruction is the first of its kind, so far as we know. Traube and Mendelssohn used paper plugs and Lichtheim sticks of laminaria. They introduced these obstructions through an opening in the trachea by long, curved forceps.

The filling up of the balloon with an opaque solution allowed us to locate it easily under the fluoroscope and to measure its diameter. Serial roentgenograms were taken of all our animals.

#### PHRENICOTOMY

We have not been able to produce atelectasis of the lungs by section of one or both phrenic nerves. The corresponding diaphragm under the fluoroscope was higher than the other and immobile, sometimes presenting slight movements. We often noticed the "paradoxical movements" described by Lemon, *i. e.*, the ascension of the diaphragm with inspiration and its descent with expiration.

In one dog (210) the pneumographs were connected so as to register on the drum any changes in the respiration during operation. The pneumographs were fixed on the animals with hooks screwed into one spinal apophysis and into the sternum, as previously described. We give the protocols of three experiments, dogs 211, 216 and 217. In the first, 211, both phrenic nerves were sectioned, the right first, and the left five days later. The respiratory tracings were taken during the operation. The times of pinching and cutting the nerve were recorded. Special disturbance was not noticed in the respiratory rhythm of the affected side. The first operation was conducted under ether anesthesia (the iso-amyl-ethyl barbituric acid given was insufficient) administered by slight intratracheal insufflation. The second operation was carried on solely under iso-amyl-ethyl barbituric acid anesthesia.

adjectives "active" and "passive" the etiologic attributes we should call them "obstructive massive collapse" and "compressive massive collapse"

The definition which we propose for this condition is obstructive massive atelectasis of the lung is a febrile complication which appears within a few days after operation, generally on the abdomen, and is always due to a more or less temporary but complete obstruction of a bronchus, and followed by the more or less complete absorption of vesicular air in the corresponding portion of lung, thus giving the organ the structure of a "fetal lung" It is especially and often conclusively characterized by the clinical symptom of a unilateral pulmonary consolidation with displacement of the mediastinum and the heart toward the affected side Its prognosis is generally favorable and ends in lysis or crisis The treatment is bronchoscopic aspiration of the obstructing mucus as early as possible

#### HISTORY

Numerous cases are reported in the literature It is interesting to notice that excellent descriptions and experimental studies had been made long before the relatively recent papers of Pasteur, but they were more or less completely forgotten

It seems that the first description of this condition was given by Legendre and Bailly, French authors, in 1844 as a frequent complication of bronchitis in children They separated it from the inflammatory consolidations of the lung, with which it was formerly confounded They defined it as a fetal condition of the lung (*état foetal*), because the lung goes back to its prenatal condition They gave as its etiology "partly the imperfect respiratory movements and partly the obstruction of the bronchi with secretions" They assigned to it a rather too simple mechanism "As the air does not enter into a portion of the lung, the alveoli collapse because of the elasticity of the lung parenchyma"

Traube, in 1846, showed that artificial occlusion of a bronchial tube causes atelectasis of the corresponding portion of the lung and that the same phenomena occur when the thoracic cavity is opened But he did not believe that this was a sufficient explanation of the mechanism of the condition, and added "We are here on the borders of a ground which we shall be able to explore only by the combination of a clinical pathological and experimental investigation" Traube was not the first investigator to succeed in producing a 'collapse' of the lung by obstructing the bronchus with a plug made with paper In 1844 Mendelssohn obstructed bronchi with shot paper and gum-arabic solution and produced atelectasis He also divided the vagi and laryngeal nerves and opened the wall of the chest The latter procedures were probably only contributing factors when atelectasis was produced

The muscular layer of the aponeurosis and the skin was sutured with fine silk.

By Feb 20, 1927, the dog made an uneventful recovery, without any respiratory trouble. The only reactions on auscultation or percussion of the right side of the thorax were signs of a slight elevation of the diaphragm.

On February 23, the animal was lively, and ate and drank well, the temperature and pulse were normal, and there was no dyspnea.

On February 24, iso-amyl-ethyl barbituric acid, 66 mg per kilogram of weight, or 38 cc of 10 per cent solution was injected into the peritoneum. Complete and deep narcosis occurred after twenty minutes. Pneumographs were made and phrenicotomy was performed on the left side with the same technic as in the previous operation. Changes were not observed in the tracing (fig 2).

On March 3, an abscess developed in the back, at the place where the hooks were fixed. It was opened and dressed.

On March 16, the animal had recovered. Nothing abnormal was noted in the lungs. The dog was killed with ether.

*Autopsy*—The lungs were in perfect condition, except for a slight congestion on both sides. Collapse did not occur. Both lungs as well as small pieces cut off

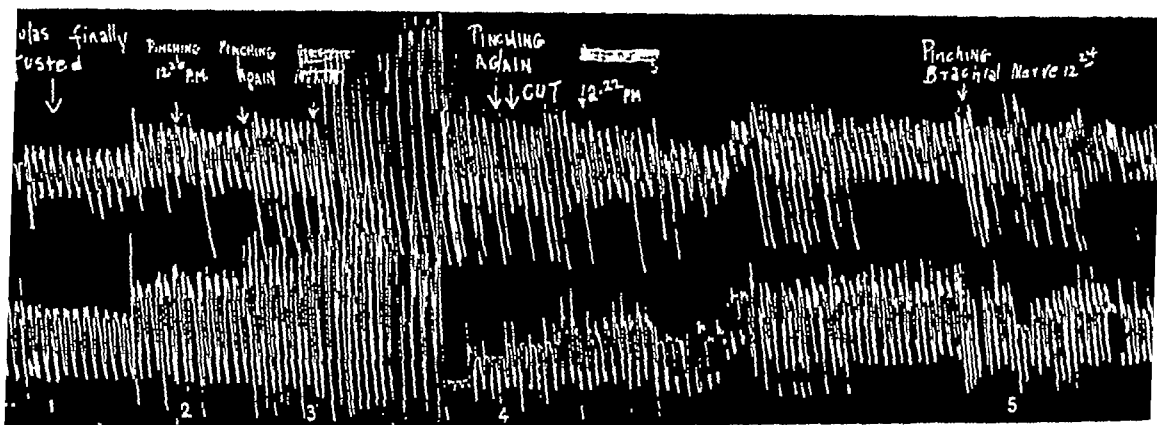


Fig 2 (dog 216)—Tracing showing respiratory movements when phrenicotomy was performed on the right side, intrapleural pressure during operation. 1 Intrapleural cannulas were adjusted. 2 and 3 Pinching produces a slight increase in respiration, apparently more marked on the left side, but immediately afterward, the movements become equal on both sides. 4 Cutting of phrenic nerve is not marked by any disturbances in respiratory rhythms. 5 Pinching branchial plexus produces an increase in respiratory movements, there is no difference between the intrapleural pressure of each side.

at the congested areas of the bases floated on the surface of water. Both phrenic nerves were cut down to the thoracic cavity (retraction after avulsion). Both diaphragmatic domes were pronounced and of equal height. The diaphragm was extremely thin, like a thin grade of paper, especially in the center, but even in the periphery it looked much thinner than normal, especially on the right side.

The intrapleural pressures recorded during section of the phrenic nerve of one side do not disclose any difference between the sides. In two experiments (216 and 217), we noticed violent respiratory movements and variations in the intrapleural pressures on pinching the phrenic nerve, owing to the superficial anesthesia. Both animals had

beyond doubt the importance of obstruction of the bronchi in the production of "collapse," and the subsequent absorption of air by the blood circulating around them. He went further and established the speed of absorption of the different gases. Thus, operating on rabbits he found that after obstruction of the bronchus, pure oxygen is completely absorbed in forty-five minutes and carbon dioxide in from ten to thirty minutes, whereas the nitrogen of air is completely absorbed only after twenty-four hours.

From that time till 1909, several articles were written on this question. General interest was again aroused by a series of papers published by Pasteur in England, from 1890 to 1914. This author noticed the coincidence of "collapse" of the lung with paralysis of the diaphragm, and, considering that there was a relation of cause and effect, he thought paralysis of the diaphragm was the principal factor in the production of massive atelectasis.

The description of Pasteur gave a new stimulus to the study of this question. The wars, too, presented a new opportunity for its study. Progress accomplished in bronchoscopic investigation, moreover, gave a new impetus to search out the etiology and the mechanism of this clinically well defined syndrome.

Briscoe, Scrimger, Pearson-Irvine, Schroeder and Green, Gralev and Hewitt, Rose-Bradford, Crymble, Sante and Brennemann, and especially Chevalier Jackson and his associates have published important papers on the subject. The contribution of Chevalier Jackson and his associates to the knowledge of massive atelectasis because of the perfection of bronchoscopic investigation, has been outstanding during the last years, it is partly responsible for clearing up the etiology and treatment of this complication. Since attention has been attracted to massive atelectasis of the lung, its clinical diagnosis has become common and the condition separated from postoperative bronchopneumonia, congestion and pneumonia, with which it was previously confounded.

Despite the number of these papers, so far as we know there has not been any systematic, experimental contribution to the knowledge of the causes and mechanism of this condition since Lichtheim's remarkable work in 1879, although the use of the bronchoscope—unknown to Lichtheim—should facilitate to a great extent the experimental study and render it much more accurate. The reason for this we believe is the difficulty of experimentally producing in a sure way, a "collapse" of the lung. To do this it is necessary to insist on the *sine qua non* condition of complete and air-tight obstruction of the bronchus in order to produce atelectasis of the corresponding occluded bronchial territory. The gradual perfection of our 'occluding balloon' took much time and trial, and there were many disappointments. When the

right side of the diaphragm was higher than the left (fig 4), whereas in the following roentgenogram (fig 5), which was taken one-half hour after phrenicotomy was performed on the left side, the left side of the diaphragm was shown to be higher than the right, under the fluoroscope, the left side showed little mobility and paradoxical movements. Five days later, the right lower bronchus was blocked with our balloon, which was filled up with saturated solution of potassium bromide so as to make it visible. In a roentgenogram (fig 6) taken twenty-two hours after the blocking, "collapse" of the lower right lobe was apparent, the heart had shifted toward the right side and the right

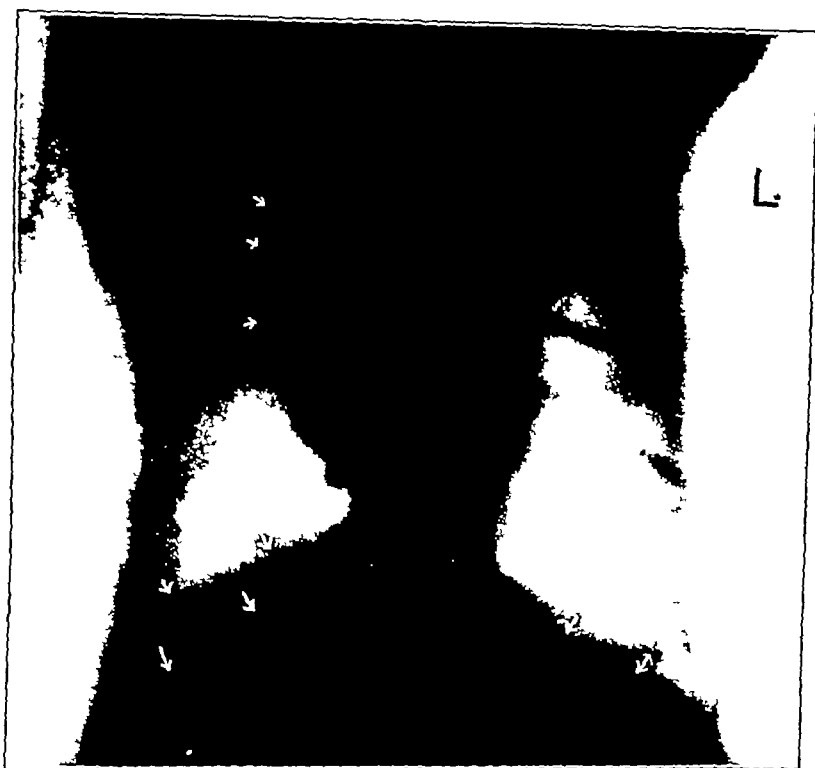


Fig 4 (dog 242) —Roentgenogram taken before phrenicotomy was performed on the left side, double exposure on the same film, inspiration and expiration, right side of the diaphragm is higher than the left, excursion of the diaphragm is indicated on the right side, left diaphragm is immobile

side of the diaphragm was much higher than the left. This showed clearly that the ascension of the diaphragm followed the "collapse," even when the other side of the diaphragm was paralyzed. The dog died two days later. Autopsy revealed that section of the left phrenic nerve had been complete and that the right side of the diaphragm was slightly higher than the left. The lower and middle lobes of the right lung had collapsed and were a dark blue-black and of leathery consistency; these lobes sank in water, and if compressed while under water did not give off air bubbles. The balloon was in place, and partially obstructed the bronchus of the upper lobe.

4 The absorption of each of these gases in the blood, according to the law of Henry, varies directly with its pressure, that is it increases and decreases proportionately with the rise and fall of the pressure of gas in the alveoli, the temperature remaining the same. It follows that in a mixture of gases, each gas is dissolved in proportion to the pressure that it exerts and not in proportion to the pressure of the mixture. Besides this law, we must consider the "absorption coefficient" which is the number that expresses the proportion of gas dissolved in a given volume of the liquid under one atmosphere of pressure and at a given temperature. The absorption coefficients for oxygen, carbon dioxide and nitrogen are, oxygen, 0.0262, nitrogen, 0.0130, and carbon dioxide 0.5283 at 40 C (Howell). The solubility of carbon dioxide therefore is twenty times as great as that of oxygen. Knowing the pressure in the alveoli, we may calculate how much of these three gases can be held in the arterial blood in physical solution. If we admit that in rough numbers the composition of the alveolar air is 80 per cent nitrogen, 15 per cent oxygen, and 5 per cent carbon dioxide, we find that in 100 cc of water, the following amounts should be held in solution: nitrogen, 1.04 cc, oxygen, 0.393 cc and carbon dioxide 2.64 cc. The foregoing figures are correct for water, but are not for the blood, in which, because of the presence of oxyhemoglobin the conditions of solubility and tension for oxygen and carbon dioxide are changed. Thus, 100 cc of blood actually contains 20 cc of oxygen and from 40 to 45 cc of carbon dioxide, whereas there is only 1 cc of nitrogen which does not play a direct role in the physiologic processes and so is held in the blood in physical solution and absorbed by the blood in proportion to its partial pressure in the alveoli in accordance with the law of Henry. Pflüger, analyzing the arterial blood of the dog, obtained the following figures, reckoned in per cent by volume: oxygen, 22.6, carbon dioxide, 34.3, nitrogen 1.8.

Thus in the case of complete obstruction of a bronchus by a plug or a ligature, the intra-alveolar pressure will be increased because of the elastic pull of the alveoli the capillary circulation of which is in contact with the contained air. This air will be absorbed by the blood: the carbon dioxide rapidly, the oxygen, less rapidly, and the nitrogen slowly. Our experiments on the mechanism of atelectasis confirm these facts.

5 The innervation of the bronchial musculature is important in a consideration of the production of atelectasis as many authors say that the reflex contraction of the muscular ring of the bronchioles explains the shutting off of the alveoli. It is admitted that this musculature is supplied through the vagus with motor and inhibitory fibers called bronchoconstrictors and bronchodilators. Stimulation of the constrictors

closed hermetically. The groove is filled with mercury or preferably with petrolatum, so that a perfect seal is obtained. The box has three outlets, two of them are 1.3 cm in diameter and the third, 0.3 cm. The first outlet is connected with a rotating valve (*V*) which produces an oscillating vacuum. The valve is rotated slowly by a home-made two-pulley speed reducing mechanism consisting of a wheel (*W*)



Fig 6 (dog 242) —Roentgenogram taken twenty-two hours after obstruction of the right lower lobe with balloon, balloon is filled with bromide solution, the heart shifted toward the right, the right side of the diaphragm is higher than the left which is paralyzed, atelectasis of the right lung

and a motor (*M*) with a rheostat installed. An extra 40 watt lamp resistance (*L*) in the system further reduces the speed of rotation. The valve can be regulated to perform only from fifteen to twenty revolutions a minute, simulating the respiratory movements. The

paralysis, in twenty-eight of which the diaphragm was involved fifteen of these had a fatal issue, and autopsy was performed in eight. In five of these, there was clear evidence of paralysis of the diaphragm for several days before death, and in each of these cases the lower lobe of the right lung was collapsed and entirely devoid of air. This coincidence is impressive, but there were two cases of "collapse" in which paralysis of the diaphragm was not present, and a third in which the paralysis had disappeared twenty-four hours before death. The absence of paralysis of the diaphragm in those three cases greatly weakens Pasteur's theory. There are other far stronger arguments against this theory, especially physiologic ones.

The mechanism suggested by Pasteur is as follows:

"As the expression of the air of the lungs at birth is primarily due to muscular effort and is subsequently maintained by the balance between the forces which cause expansion and contraction, respectively, it follows that whenever—whether as the result of paralysis or of temporary inhibition—the distending forces acting on any part of the lung becomes less than that of the agencies which tend to cause it to contract, the latter forces take charge, with the result that the part of the lung concerned rapidly empties itself of air." Pasteur claims that the mechanism here suggested—active contraction—differs from that generally accepted in explanation of collapse, namely, gradual absorption of the contained air from a portion of the lung which has been shut off from communication with the external air by occlusion of the air ways. He accepts only two causes in the production of massive "collapse": compression of the lung by the diaphragm and diminished respiration.

But this cannot explain the complete emptying of the air in the lung by the slight compression due to the ascension of the paralyzed diaphragm. The minimal air remains in the lung even after wide opening of the thoracic cavity, and only later is the air gradually absorbed, if the animal survives. Even with marked compression of the lung by abundant effusion of fluid or pneumothorax the absorption of the minimal pulmonary air is gradual, the carbon dioxide being absorbed most rapidly, then the oxygen and finally the nitrogen, this shows that the disappearance of the air is due to a more complex mechanism than a merely mechanical one. The same phenomenon occurs in the ligation of a bronchus (Lichtheim). In these cases the absorption of air obeys the same physicochemical laws.

The often reported sudden onset and disappearance of the symptoms of atelectasis after expectoration of thick sputum cannot be explained by this theory, although Pasteur believes that the bronchus of the affected lobe is secondarily filled with secretions. It is unfortunate that Pasteur does not indicate in the reports of the cases which came to autopsy whether or not mucous plugs were present in the bronchus.



rotating valve is connected at one end with a suction machine or the ordinary laboratory suction faucet. The other end of the rotating valve connects directly with the box (outlet 1). The second tube (2) is connected with a water manometer. The third tube (3), covered with a piece of rubber tubing and stop-cock, connects the box with the outside air, regulating the degree of vacuum in it. At the opposite panel of the box is a circular opening bearing a cylindrical collar (C) of soft rubber tissue which can be adjusted around the shaved neck of the dog and fixed with a bandage so as to be airtight.

Our technic was simple. The animal was anesthetized with iso-amyl-ethyl barbituric acid. The neck was then shaved, the anterior wall of the chest prepared, and intratracheal insufflation started. The

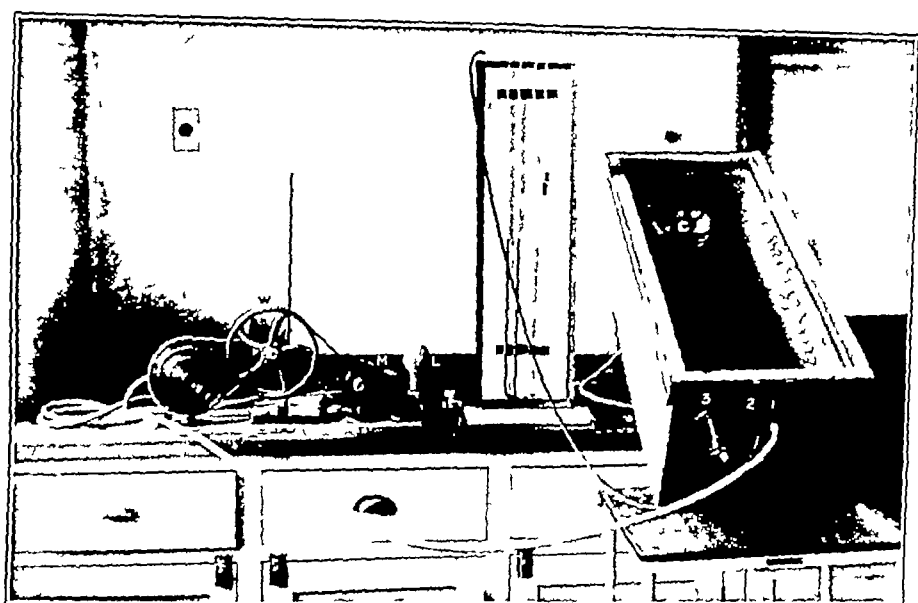


Fig 8—Box for oscillating vacuum. 1, 2 and 3 indicated outlets, *V*, rotating valve, *W*, wheel, *M*, motor, *L*, 40 watt lamp resistance and *C*, a cylindrical collar

thorax was then opened by hemisection of the sternum as in the technic of Gregoire, and a Balfour retractor was applied to maintain the thoracic cavity wide open. As there is but one pleural cavity in the dog, physiologically speaking, it did not matter if both cavities were exposed. The animal was then introduced into the box through the circular opening or through the top of the box, as temporary interruption of respiration does not have any evil effect. The cover was tightly applied and the rubber collar fixed around the neck of the animal, smeared with petrolatum and secured by a gauze bandage. Care was taken not to exert any unnecessary constriction around the neck.

The suction faucet was opened and the rotating valve set in motion. By regulating the opening of the suction faucet and of outlet 3 of the box, we easily obtained a negative pressure oscillation between 3 and

Briscoe reported various degrees of collapse in rabbits after phrenicotomy, but, curiously enough, the collapse was not limited to the affected side, but was often bilateral and frequently was more extensive on the other side. We believe that in these experiments there were probably congestive lesions of the lungs. Martin and Hare are quoted by Pasteur as having noticed 'bilateral collapse' in an animal dying after a bilateral phrenicotomy, and Schroeder and Green admitted that phrenicotomy could produce 'collapse' of the lower lobe. The contentions of the last authors do not seem to be backed by sufficient experimental proof.

Rose-Bradford in his exhaustive paper, did not admit the theories of Pasteur. He analyzed cases of collapse secondary to gunshot wounds. In the cases of perforation with hemothorax he explained the production of 'collapse' by the possible blocking of a bronchus by clotted blood or by compression of the lung. The explanation becomes more difficult in the cases in which there was a slight wound of the thoracic wall without penetration or even fracture of a rib. In these cases the collapse may not only be homolateral but even contralateral. Collapse constitutes a rather frequent complication of a slight thoracic wound about 10 per cent according to Bradford. One of the most typical cases reported in his paper is that of a soldier who received a superficial wound in the wall of the chest; he walked four miles to a dressing station, where the bullet dropped out of the wound. He was sent back to the base hospital and did not complain of any symptoms. The same night he was found to have a contralateral collapse. Bradford explained these cases in particular and the collapse of a lobe or more by immobility and retraction of the chest-wall due to constrained posture and prolonged recumbency; insufficient expansion of the chest whenever prolonged is capable of causing collapse. He further added: 'It is as a result of cessation of respiratory movements the chest should become fixed in an extreme expiratory phase the air in the lungs would not be adequately removed and the air present would be absorbed by the blood-stream; this collapse might be brought about.'

This theory is contrary to physiologic facts for it is in defiance of the fact that complete evacuation of a pulmonary airway would be produced by expiration however extreme with absorption of the air by the circulating blood under these conditions. Although Bradford admitted the production of this chest-wall condition remains most obscure, he remarked on the other hand that there is definite positive evidence that massive collapse may be present and yet no obstruction of the bronchi be found. Hence obstruction of the main bronchi may be excluded as a common or probable cause of the condition. Yet he admitted that obstruction of small bronchioles may be sufficient to

11 50 a m The animal was placed in the box As soon as the vacuum was established, the rhythmic expansion of the lungs started, filling the thoracic cavity completely with each inspiration The rate of the valve was 18 a minute, the spontaneous respiratory movements of the animal, 9 a minute The valve rate was increased to 24 a minute, the spontaneous respiratory movements slowed down to 5 By changing the valve rate to 12, we obtained a synchronization with the spontaneous movements of the chest

12 30 p m The right main bronchus was blocked with a balloon

1 00 The size and color of the right lung did not change A second balloon was introduced and inflated Immediately there was marked shrinkage in the upper and middle lobes The left lung (distended) took the place of the shrunken lobes and pushed the heart to the right side Apparently the first balloon was not sufficiently inflated When the second balloon was introduced, it seemed to impinge against the orifices of the two superior secondary bronchi, whereas the first balloon, which was placed near the internal wall of the main bronchus, prevented the complete contact of the second balloon with this internal wall, thus complete occlusion of the bronchus of the lower lobe was impossible

1 30 There was marked deflation of the two upper lobes Dark blue spots formed on the surface of the lung Marked dyspnea was not present, the spontaneous respiratory movements of the animal were not increased in number

2 00 The upper lobes were still more shrunken and the dark blue spots became more and more confluent

5 00 The heart beat was strong The manometer oscillated between 1 and 4 cm of water The upper and middle lobes of the right lung were much shrunken and immobile The heart was displaced more to the right

6 00 The suction apparatus suddenly went out of commission The animal died

*Autopsy*—The upper and middle right lobes were shrunken and bluish-black, the trachea being clamped The left side of the lung was normal The lower right lobe was slightly cyanotic, but normal in consistency On palpation, the resistance of the two upper right lobes increased and very few air bubbles came out on compression as compared to the other lobes, pieces of the upper and middle right lobes barely floated, whereas pieces of the other lobes floated readily The lower balloon was found disinflated, substantiating our surmise

EXPERIMENT 5 (dog 224) —A mongrel, male terrier, weighing 9 Kg, was used

March 21, 1927, 10 40 a m The animal was put to sleep with iso-amyl-ethyl barbituric acid, 70 mg per kilogram of body weight

12 45 p m Midsection of the sternum was performed, which was then held closed with clamps

1 45 The animal was placed in the box

1 55 By means of an aspiration tube placed through the bronchoscope, oxygen was introduced under pressure into the right bronchus for a period of over five minutes

2 00 A balloon was introduced into the right lower bronchus The animal breathed synchronously with vacuum even when the rate was changed The clamps on the chest were removed every hour, and the condition of the lungs was noted

3 00 The right lower lobe seemed to be very much shrunken The left lobes were much larger and extended further toward the right side than previously

4 00 The heart beat was strong The rate of respiration was 21 of the vacuum rate The right middle lobe was not seen The right lower lobe seemed to be shrunken and almost hidden behind the heart

lapse" observed in obstruction of bronchi by foreign bodies and in experimental obstruction. The usual agent of this obstruction appears to be a plug of mucus. Before studying the arguments in favor of obstruction of a bronchus, we deem it necessary to examine rapidly some other theories proposed to explain massive 'collapse.

Under this heading, we find incomplete mechanical obstruction by (1) a reflex contraction of the bronchial muscles, (2) a swelling of the mucosa (Briscoe) comparable to angioneurotic edema (Scott) and (3) a vasomotor reflex (Scott). These authors bring in clinical and experimental support in favor of the reflex idea as a determining cause of massive "collapse." The clinical symptoms are the sudden onset, the persistence of tubular breathing over the affected area and the rapid change in stethoscopic symptoms as in case 38 of Scott in which musical rales were present in abundance throughout both sides of the chest when the patient was examined. When the patient was reexamined half an hour later, only a few rales were present on the affected side and some on the opposite side, furthermore the vital capacity showed a greater diminution than would be expected from complete suppression of the function of a lung. Experimental data in favor of the reflex mechanism are those obtained during the experimental work of Carlson and Luckhardt, who produced contraction of the 'sack-like' lung of amphibians by electrical or mechanical stimulation of the nasal passages, small and large bowel, kidney and bladder, also the bronchial spasm or swelling of the mucosa in anaphylactic shock in the guinea-pig.

While the foregoing reflex phenomena may be contributory causes by facilitating the accumulation of mucous secretions in the bronchial tree with subsequent occlusion, we believe that they alone are unable to produce atelectasis. *Spastic contraction of the bronchial muscles moreover, produces emphysema and not collapse* likewise emphysema is produced in (a) reflex asthma due to irritation of the nasal membrane, (b) allergy or (c) anaphylactic organ-shock in the lung of the guinea-pig. The contraction of the bronchial muscles which was considered a cause of atelectasis of the lung certainly occurs in acute anaphylactic shock in the guinea-pig. The dominant pathologic feature in these animals is the tetanic contraction of the smooth musculature of the bronchioles (Auer and Lewis), owing to hypersensitiveness of the smooth muscle tissue which is also observed in other organs in the same animal. The lung in these animals is not only not collapsed but on the contrary is inflated. This inflation not only remains maximal after the removal of the lungs from the chest but resists reduction with moderate pressure (Couch).

The lung in the rabbit is rather diminished in volume owing to the spastic contraction of the arterioles of the pulmonary artery by

the typical symptoms of atelectasis (apneumatoxis), i. e., dyspnea, cough, diminution of normal resonance on the affected side progressing to dulness and shifting of the mediastinum toward the same side, with a more or less marked rise of temperature. The production of the condition is so typical after the complete occlusion of a lung that when it was not produced, we were certain that something was wrong with the balloon and that obstruction was not complete. The case of dog 232 proves this.

EXPERIMENT 6 (dog 232) —A female fox terrier, weighing 10 Kg, was used May 26, 1927, 10 30 a. m. Iso-amyl-ethyl barbituric acid, 65 mg per kilogram of weight, was administered.

10 45 The dog slept deeply. A roentgenogram of the chest was taken.

11 00 The right main bronchus was blocked and 7 cm. of saturated potassium bromide solution was injected into the balloon.

11 15 A roentgenogram was made. Clinically, the heart did not shift nor was there any displacement of the heart toward the right side. In order to find out whether the balloon was inflated or not, a lateral roentgenogram was taken, which showed that the balloon was not inflated.

12 10 p. m. The balloon was extracted through the bronchoscope. A new balloon was introduced into the right bronchus. A lateral roentgenogram was taken, which showed that the balloon was well blown up.

1 00 A clinical examination showed that the heart had shifted to the right, and that there was dulness at the base on the right side, with absence of vesicular murmur. There was tubular breathing over the upper part of the thorax on the right side, accompanied by wheezing.

5 00 Five hours after blocking, opacity of the lower right lung, displacement of the heart to the right and ascension of the right side of the diaphragm were noted.

4 00 a. m. On May 27, sixteen hours after blocking, atelectasis increased. The heart was not visible to the left of the sternum. The animal was dyspneic, with complete dextrocardia.

3 30 p. m. The balloon was removed. A roentgenogram taken ten minutes after removal showed the right side partly cleared up and the heart again markedly visible on the left side. The right side of the diaphragm was still higher than the left.

10 00 Six and a half hours after removal, the right side of the thorax was clear, the heart had come back to its normal position and the right side of the diaphragm was almost at the same level as the left. The clinical symptoms had completely disappeared.

May 28, 10 30 a. m. Nineteen hours after removal of the balloon, recovery was complete. The diaphragm was at the same level.

In dog 246 (figs 9, 10, 11), atelectasis was clearly shown by the three roentgenograms. Complete occlusion of the left bronchus was demonstrated by iodized oil 40 per cent injected into the trachea, none of the oil penetrated the left bronchus. The base of the right side of the lung had encroached on the left side, and traces of the oil were visible.

contributing causes from the determining cause. The first are (1) embarrassment of respiratory movements of the wall of the chest or of the diaphragm from any cause, be it paralytic reflex as from pain or mechanical, as from posture, (2) increased bronchial secretions caused by irritation or infection of the bronchial mucosa bronchitis or pneumonia, (3) decrease or abolition of the cough reflex (the watch-dog of the lungs," as Jackson picturesquely calls it) as a means of avoiding pain or due to the use of narcotics. There is only one determining cause, i. e., the complete obstruction of a bronchus by a plug acting as a foreign body, or by compression from the outside.

The theory of the obstructive nature of atelectasis is not new. As we have already mentioned, Mendelssohn, in 1845, and Traube in 1846, succeeded in producing this condition by plugging the bronchus with paper balls. Lichtheim, in 1879 published the results of his remarkable experimental work in which he used rabbits, plugging their bronchi with sticks of laminaria introduced through an opening in the trachea and controlling the results by opening the thoracic cavity from time to time. Although he could not use either the bronchoscope or the roentgen ray, he obtained accurate results. He was not only able to produce a typical atelectasis each time but he showed that the carbon dioxide was absorbed far more quickly than the oxygen and the oxygen more quickly than the nitrogen in accordance with physico-chemical laws. This was the first demonstration that atelectasis is due to absorption of alveolar air by the blood circulating in the alveolar capillaries. Plugging of a bronchus or ligature of it without ligation of the pulmonary and bronchial vessels was followed by complete absorption of the contained air within twenty-four hours. But if the vessels are comprised in the ligature, the lung becomes edematous and more or less necrotic, and the air does not completely disappear. The paradoxical occurrence of the edema of the lung (which means persistence of circulation to some degree even after ligature of the pulmonary artery, the vein and even the bronchial vessels) is due to the fact demonstrated by Kuttner that small branches are given to the lung from the pericardial esophageal and mediastinal vessels.

According to Lichtheim, after ligature or complete obstruction of a bronchus the corresponding lobe or lung in rabbits becomes airless in from about two and one-half to four hours. During the first hour the decrease of volume is rapid, but the lung conserves its normal color. During the second hour the lung shrinks more and more. Then on its surface black-red islands appear which gradually become confluent as the lung becomes airless. This irregular appearance of atelectasis is due to the fact that the activity of the capillaries of the lung as well as of other organs varies in different parts of the

We do not think it possible to have a more convincing experimental proof of the relation between obstruction of a bronchus and atelectasis of the corresponding side of the lung, and of the necessity of having this occlusion complete. The experiments also show that atelectasis disappears as soon as the obstructing agent is removed. The same



Fig 10 (dog 246) —Roentgenogram taken twenty-five minutes after blocking, 2 cc of iodized oil 40 per cent was injected into the trachea above the balloon by bronchoscope. Note that none of the iodized oil has entered the left bronchus, the right lower lobe has encroached on the left base, the diaphragm is high on the left and the shifting of the heart.

phenomena are reproduced when the balloon is disinflated slowly and spontaneously because of a small leak at its neck. Roentgenograms of dog 255 (figs 12, 13, 14) show this clearly.

which latter we shall borrow liberally) up to the present day. It is known that atelectasis may occur following (1) ligation of a bronchus (2) obstruction of a bronchus, (3) opening of the thoracic cavity and (4) compression of the lung by fluid or air present in the thoracic cavity. The question arises whether the real cause of atelectasis is always the absorption of the air by the circulating blood.

1 *Atelectasis Following Ligation of a Bronchus*—We have seen that carbon dioxide, oxygen and nitrogen of the air are completely absorbed in a time varying according to the size of the animal from two and one-half to four hours in rabbits and three days in dogs and that the carbon dioxide is absorbed more quickly than the oxygen and this more quickly than the nitrogen. These are experimental facts. There are now fewer difficulties in the way of explanation of absorption. In fact, absorption of alveolar air by the blood of the capillaries can take place only if the absolute and relative tension of the gases of the alveolar air is greater than the tension of the same gases in the blood. This is possible only if it is admitted that the elasticity of the tissue of the lung is not exhausted before a complete contact of the alveolar walls is effected. If the alveoli of the lung were like myriads of toy balloons in which, even after complete spontaneous deflation, a cavity with air still remained, an equilibrium would be established between the gases of the alveolar air and of the circulating blood, and no more absorption would occur.

Against this hypothesis of perfect elasticity of the lung is in appearance at least, the fact that if the thoracic cavity is opened widely (without ligation of the bronchus), the lung collapses but does not become atelectatic, i. e., airless. The minimal air still remains and a piece of this lung floats in water and gives off air bubbles when expressed under water. The same aeration is observed in the lung of the cadaver. This objection however, is only apparent because in the living animal (as Traube first showed), the lung becomes blackish blue and airless in from one to two hours after the opening of the thorax. The explanation of the deferred atelectasis is that because of collapse of the walls of the small bronchioles of the contraction of their muscular ring (Bartels) and of the length of the bronchial tree a resistance to the complete exit of air is offered but the air which remains in the alveoli is compressed above atmospheric pressure and so is absorbed by the circulating blood. This is obvious because if the alveolar air were not under a pressure greater than the atmospheric air if the bronchi were open, air would enter the alveoli to replace that which had been absorbed if absorption could take place under such conditions. This consideration leaves no doubt that the elasticity of the lung is exhausted until all the air is expelled (or rather absorbed) and that the lung comes back to its prenatal atelectatic condition.



Space does not allow us to deal with these questions in detail, they will be elaborated in subsequent papers. We shall give briefly the results of our investigations, which we are continuing, especially those made to localize the infection in the atelectatic lung.

1 The time necessary for the establishment of atelectasis when the lung is filled up with oxygen is short. Immediately after the occlusion, the heart is markedly shifted, and after one-half hour the atelectasis seems complete. Atelectasis is a much slower process when there is air in the lungs, although by roentgen-ray examination the process is marked by the sixth hour.

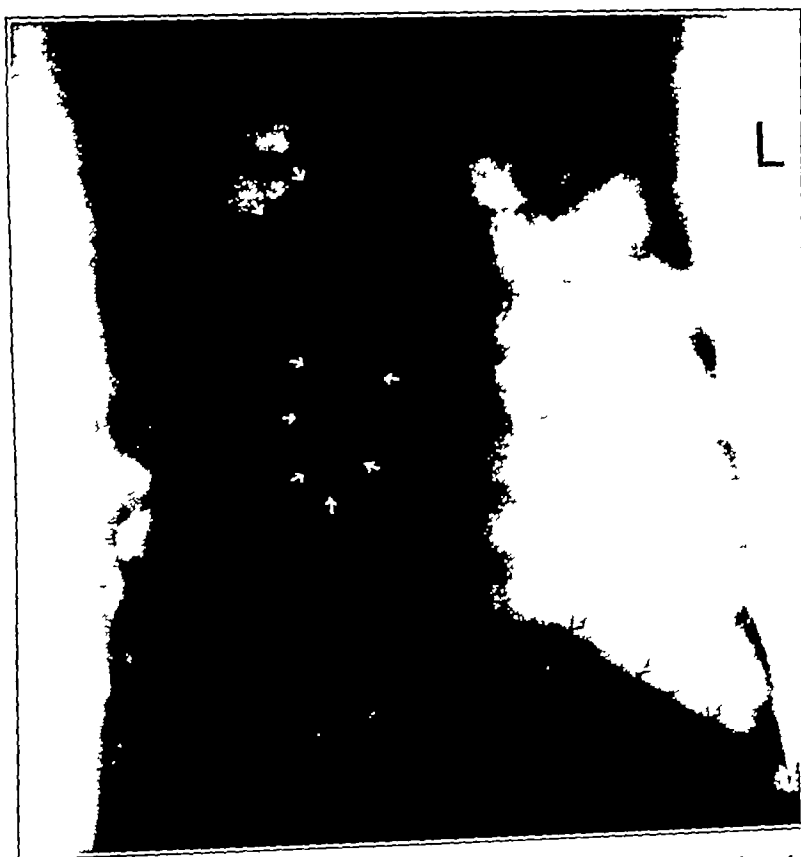


FIG. 12 (dog 255) —Roentgenogram taken twenty-four hours after blocking, atelectasis of the right lower and median lobes is noted, balloon is well blown.

2 The most frequent complication of the condition is a diffuse suppuration—a real purulent pneumonitis of the lung, bronchial in origin. Other types recognized in our sections, which were examined by Drs. L'Esperance and Symmers, were acute exudative pneumonia, acute hemorrhagic pneumonitis (as in influenza) and typical bronchopneumonia. The most frequent agents in this infection were staphylococcus, streptococcus and especially *B. coli* and anaerobes.

3 Even when infection of the bronchus seems advanced and the animal is already in poor condition with a temperature as high as

hours may elapse between the ligation of the pulmonary vessel and the establishment of a hemorrhagic infarct. Thus since the normal lung (with the chest open) becomes completely "airless" in from one to two hours, there is a sufficient margin of time for comparative observation and deduction. From six to eight hours after the ligation of the pulmonary artery, the lung will become smaller because it has been emptied of blood, but only its surface, to a depth not exceeding from 1 to 2 mm. has become atelectatic. Its center is full of air. This airlessness on the surface is a phenomenon independent of the circulation, because it is observed even in the cadaver's lung when it is exposed to the air and is due to the expression of the alveolar air through the alveolar walls. That the air is not expressed through the airways is proved because (1) the phenomenon is not observed in the cadaver when the thoracic cavity is closed (when there is no air around the lung) and (2) the same phenomenon is noticed even when the lung is extracted from the chest and one of the main bronchi is ligated. In the second instance both lungs contain the same amount of minimal air at the moment the peripheral atelectasis will advance to the same degree in both. According to the foregoing facts, there can be no doubt that the principal cause and the mechanism of atelectasis is the absorption of alveolar air by the blood.

4 *Atelectasis Caused by Compression of the Lung by an Exudate*—The mechanism, in our opinion, remains the same. The portion of the lung submerged in the fluid is in the same condition as if the thoracic cavity were open. The intrathoracic negative pressure is absent and thus the part of the lung submerged collapses exactly as if the chest were open, the remnants of minimal air are gradually absorbed by the blood. The proof of circulatory absorption lies in the fact that atelectasis is noticed not only when there is abundant exudate filling up practically the whole pleural cavity but even when there is a moderate amount. The process is to a great extent independent of the quantity of fluid. Yet even in this condition the possibility of bronchial obstruction by an accumulation of mucus due to disturbance of respiratory movements must not be forgotten.

We have told what we know about this puzzling question of atelectasis of the lung. We have tried to give as complete an exposure of the mechanism and etiology as we were able. Many phases of the question seem to have been cleared up during the last few years especially since Pasteur called the clinicians' attention to the occurrence of the possibility of its clinical diagnosis. The roentgen-ray and bronchoscopic examinations have helped in no small measure. Yet it is true that even the most recent papers on this question leave a great uncertainty in the minds of the clinician.

even abscess of the lung, because of the fixation of septic emboli in the tissue of the affected lung, which would not produce complications in a sound lung. Our investigation of this problem is not yet finished. It presents important technical difficulties, chiefly because of the suppurative pneumonitis which, as a rule, follows occlusion in the dog, probably because of *B. coli* and other organisms (present in the mouth and pharynx) which the balloon carries down into the lung. We will give here only two roentgenograms (figs 15, 16) of dog 251 in which



Fig 14—Roentgenogram taken twenty-four hours after the balloon was coughed up, the right lung is almost entirely clear

the lung showed a diffuse suppurative bronchopneumonia after intravenous injection of a special *B. coli* strain after blocking. The *B. coli* cultured from pus in the small bronchioles was not identical with the culture injected and corresponded to the *B. coli* normally present in the mouth and pharynx of the dog. The cultures were supplied and the bacteriologic work controlled by Drs J. C. Torrey and M. C. Kahn.

5 The gross and microscopic pathologic processes in our experimental atelectasis are typical. Figure 17 is a gross photograph taken

coils and consequently by changes in the amplitude of the graphs. We avoided this to a great extent by fixing the instrument directly on the animal.

The intrapleural pressure was measured by connecting a double water manometer comparable to the one used by Lemon or two tambours for tracings with two thoracic cannulas, as used in our physiology department. The cannulas were thrust into the respective thoracic cavity through the intercostal space after a small incision had been made in the skin. In this way we avoided any leakage between the cannula and the wall of the chest and any injury of the delicate tissue of the lung of the dog which would produce pneumothorax.

For the obstruction of the bronchi we used a specially constructed inflatable balloon introduced through the Jackson bronchoscope. The construction (fig. 7) of this balloon has been the most laborious and difficult part of our technique. We were looking for a device which would obstruct a given bronchus completely or incompletely as we wished, and the degree of inflation of which we would at the same time be able to check up with the roentgen ray. In this way we would be able to determine the relation between the degree of obstruction and the degree of atelectasis produced. Previous attempts at obstruction with foreign bodies of various kinds, such as metal, cork, laminaria sticks and plugs of cotton had been unsuccessful. In its final form, our obstructing balloon is composed of a small glass tube, 4 cm. in length and a little less than 0.5 cm. across the proximal opening of which is narrowed in the flame so as to be almost punctiform. A rectangular piece of fine rubber tissue (old glove) under slight tension is tied over the distal opening, forming a one-way valve. The tube and valve are introduced into a piece of thin rubber tubing, closed at one end, a little more than 0.5 cm. wide and 4 cm. long. The best rubber tubing for this purpose is that used on the Kollman urethral dilator. An outer covering of fine organdie is passed over this tube which is wide enough to permit the system, when inflated, to have a diameter of 1.5 cm. or more. The rubber tube and its covering are twisted so as to express the air and diminish their volume and are then tied up near the proximal end of the glass tube, leaving about 1.5 cm. of the latter free. Superfluous rubber and material are cut away near the neck of the glass tubing. In this form, however, the balloon can easily be expelled by coughing and in our experiment this happened repeatedly. Once it obstructed the larynx causing the death of the animal by asphyxia. For that reason, we fixed on its proximal end a loop of steel piano wire to catch the walls of the bronchus and oppose any tendency to displacement. The extraction of the balloon with the bronchoscope was easily accomplished by a long forceps grasping the wire. The balloon is thus inflated. Air or water can be introduced into the balloon but cannot escape. It can remain well inflated for a long time although sometimes they gradually become deflated. This slow spontaneous disinflation has been useful in certain cases. The balloon is connected by a piece of fine rubber tubing (not over 2 cm. long) to glass tubing 45 cm. long and of the same diameter as is used for the introduction of the balloon. This leaves 5 cm. of tubing protruding from the bronchoscope when the balloon is in place. A 10 cc. syringe filled with a normal saline bromide solution is connected with the long glass tubing at its proximal end. Before connecting the balloon to the distal end of the long glass tubing, the latter is filled with the same solution in order to expel the air. The apparatus is now ready for use.

The Jackson bronchoscope (9 mm. in diameter) is introduced into the trachea being followed as in man. When the area around the carina is reached the bronchoscope is withdrawn a few centimeters because of the straightness of the cervical vertebral column. The balloon is then introduced into the mouth of the animal the introduction being guided by the light from the

The microscopic aspect varies with the degree of infection superimposed on the "collapse," but in our experiments it invariably showed complete disappearance of the alveolar spaces (fig 19) comparable to the fetal lung (fig 20), marked dilatation of the capillaries, which were filled up with blood, bronchioli filled with exudate, serofibrinous or purulent, and edema of the capillary wall. Often there was infiltration



Fig 16 (dog 251)—Roentgenogram taken six days later, left lung was blocked and 1 cc of *B coli* culture injected intravenously, four days later the dog died and a nonspecific *B coli-streptococcus* bronchopneumonia was found superimposed on atelectasis

of the alveolar walls and the peribronchial spaces with polymorpho nuclears which were confluent and gave the picture of diffuse suppuration. In a few cases, necrosis of the parenchyma was observed comparable to gangrene of the lung.

It is clear from the foregoing experimental results that there is not the slightest etiologic clinical or pathologic difference between our

No changes were noticed during the pulling, crushing or cutting of the nerve and no differences between the respiratory rhythms of the two sides.

EXPERIMENT 1 (dog 211) — A white male terrier weighing 6 kg. was used.

Iso-amyl-ethyl barbituric acid 10 per cent solution was given intraperitoneally, 55 mg per kilogram of body weight or 3.3 cc. After twenty minutes ether was given by the intratracheal tube as the anesthesia was insufficient.

The pneumographs were fixed on the back and the sternum of the animal with hooks screwed into the spinal process of the seventh thoracic vertebra and the

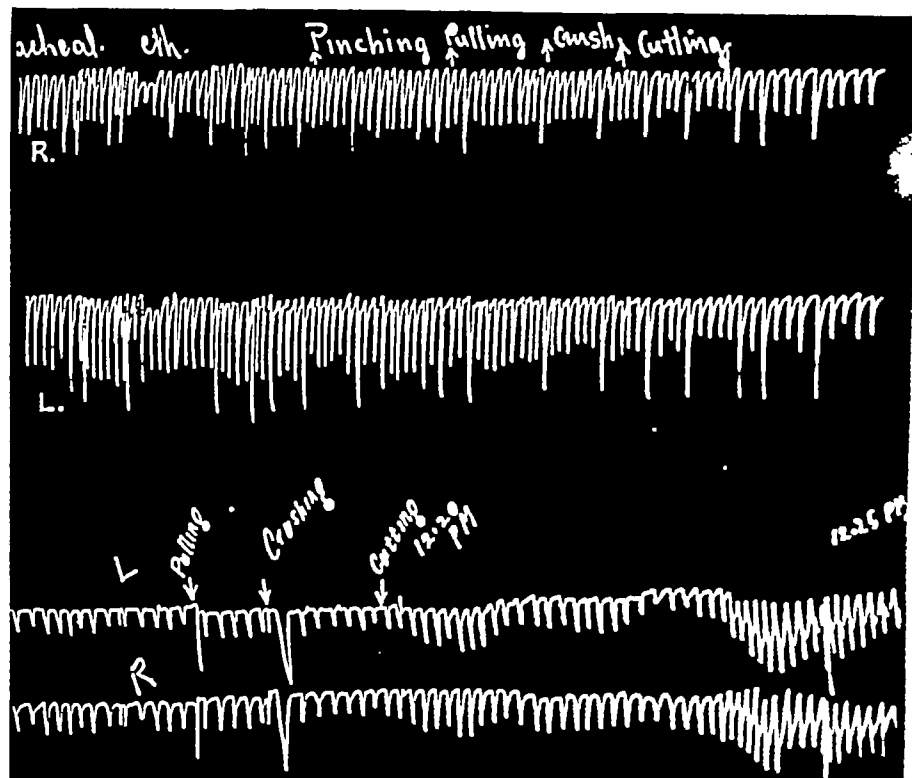


Fig. 1 (dog 211) — Double pneumograph tracings. The upper tracing shows resection of the phrenic nerve under ether anesthesia; no changes were noticed during the pinching, pulling, crushing or cutting of the nerve and no differences in the respiratory rhythm between the two sides. The lower tracing shows resection of the phrenic nerve (*L.*) of the same dog four days later; no changes were noticed. (Figures 1, 2 and 3 have been retouched.)

junction of the middle and inferior third of the sternum. The pneumographs were connected with the tambours so as to take tracings during the operation.

An incision was made in the skin behind the pectoral and under the sternomastoid which was held mesially. The phrenic nerve and its branches were cut and every branch which was thought to assist in respiration this nerve was cut. The nerve was pulled out and away from the chest.

Changes were not observed in the tracings of the phrenic nerve. The nerve was pulled or pinched without any noticeable effect. The avulsion did not produce any difference in the tracings.

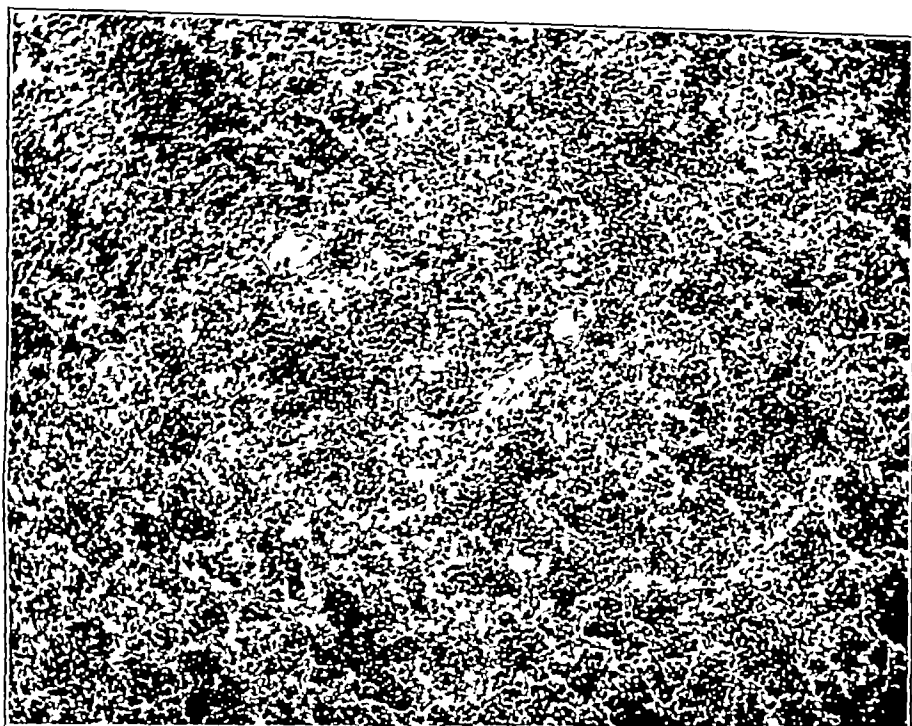


Fig 18 (dog 199) —Photomicrograph showing one of the complications (acute exudative pneumonia) engrafted on an atelectatic lung

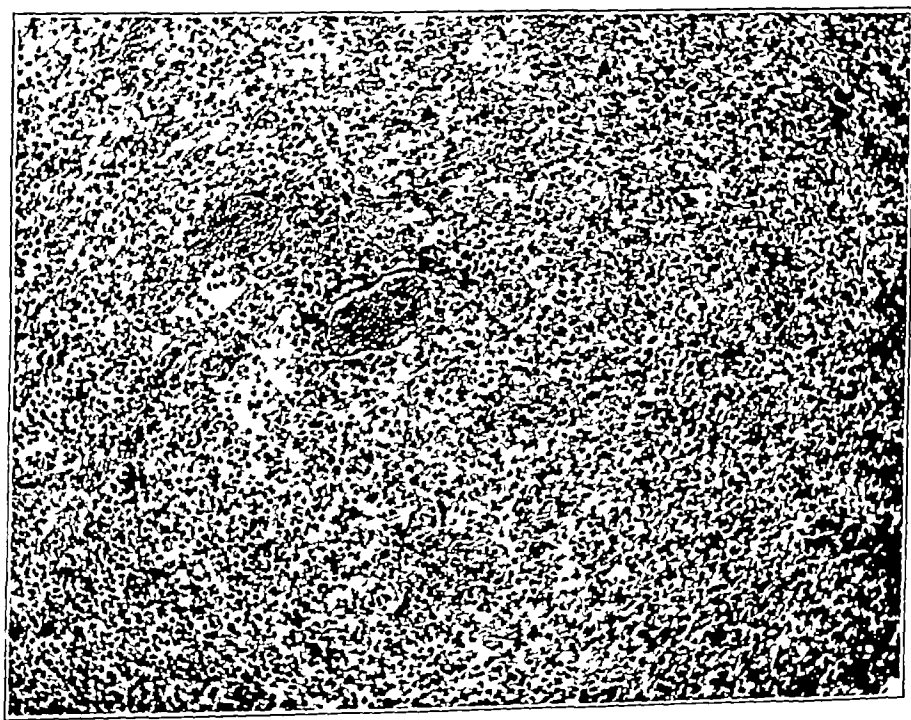


Fig 19 (dog 198) —Photomicrograph of an atelectatic lung Compare with the fetal lung in figure 20

been given iso-amyl-ethyl barbituric acid. These disturbances disappeared in a few minutes. We did not notice any difference between the two sides.

EXPERIMENT 2 (dog 216) — A white cocker-spaniel weighing 7.7 kg. was used.

On March 7, 1927, iso-amyl-ethyl barbituric acid 58 mg. per kilogram of weight, or 4.4 cc. was administered, fifteen minutes later anesthesia was complete but not extremely deep. At the fifth interspace on the right side at the axillary line, a small incision (1 mm.) was made in the skin and the intrapleural cannula, connected by a sterile rubber tubing with a tambour was forced into the intrapleural space. All aseptic measures were taken. The lever of the tambour immediately started to oscillate, which was proof that the right space had been entered and that pneumothorax was not present. The same procedure was repeated on the left side. Each intrapleural cavity was connected with a tambour. Phrenicotomy was performed on the right side with the usual technique. When the nerve was pulled or pinched, a violent respiratory movement occurred. After a few seconds, the respiration became almost normal. This disturbance in the rhythm seemed to be due to the reflex produced by the pinching because it was

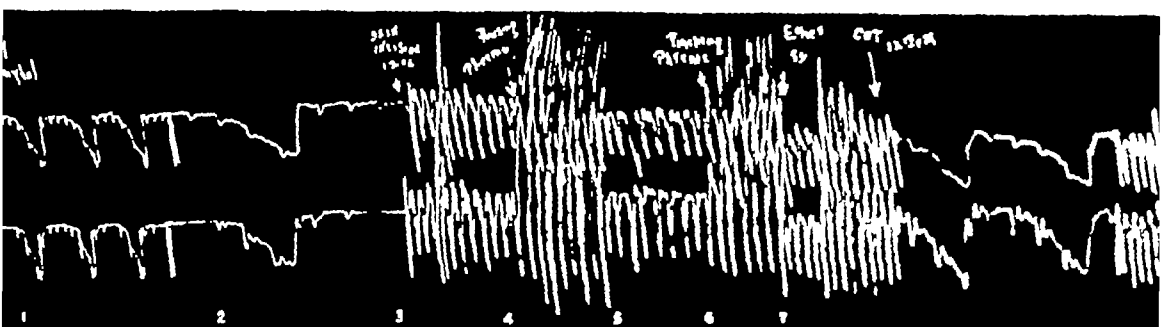


Fig. 3 (dog 217) — Tracing showing respiratory movements during intrapleural pressure. 1 Regular respiration, excursion on both sides equal (upper is right side and lower is left). 2 Slight decrease in respiratory excursion has often been noticed without any apparent cause and is of temporary duration, 12:30 p. m. 3 Incision of skin, dog reacts slightly, respiration increased. 4 Pinching of right phrenic nerve, straight respiratory excursion on both sides. 5 Respiration back to normal. 6 Pinching again, same reaction. 7 Right phrenic nerve cut, 12:18 p. m. two long respiratory movements followed by rapid respiration again.

reproduced when we crushed the brachial plexus of the animal. This did not follow (fig. 2).

The same phenomenon was produced in dog 217 under the same circumstances. Phrenicotomy was performed on the left side, but it did not follow (fig. 3).

In order to find out what would happen if an occlusion of the bronchus was performed when the diaphragm was paralyzed by section of the phrenic nerve we performed an experiment on the left side on dog 242 under iso-amyl-ethyl barbituric acid anesthesia.

A roentgenogram taken before phrenicotomy showed that



Writer	Complication or Forerunner, Location of Collapse	Age	Sex†	Deaths and Conditions Found Postmortem	Operation	Anesthetic	Onset. Symptoms	Duration	Treatment
Pearson Irvine Tr Clin Soc Lond, 1876, p 188	Diphtheria, right and left upper lobe	6	♀				4-5 weeks after diphtheria, flatness, dullness over both infrascapular regions, pharyngeal paralysis, cough	14 days	
Pasteur, W Am J M Sc 100 242, 1880	Case 1 diphtheria, right and left lower lobe	4	♂	Collapse of right and left base, bronchi not described			19 ? days after paralysis of the pharynx, 6 weeks after diphtheria	?	
	Case 2 diphtheria	4	♂	Death no autopsy done			5 weeks after diphtheria, palate paralyzed, cough on swallowing	?	
	Case 3 diphtheria, right lower lobe	4	♂				6 weeks after diphtheria, 6 days after paralysis of the palate, diminished resonance, weak bronchial sounds at base	?	Placed on left side with artificial res- piration 3 times a day
	Case 4 diphtheria, both bases ?	2	♂				5 weeks after diphtheria cough, cyanosis, tempera- ture, 102.8	3 days?	Artificial respiration every 6 hours, 15 minutes for 3 days Artificial respiration
	Case 5 diphtheria, whole right lung, es- pecially lower lobe	2	♂	Collapse of right lung and almost all of lower lobe, bronchi not described			7 weeks after diphtheria, gradual dyspnea, cyanosis	5 days? sudden	
	Case 6 diphtheria right middle and lower lobe		♂				17 days after paralysis of the trunk and limbs dyspnea, cyanosis, dimi- nished expansion of chest	2 days	
	Case 7 diphtheria	6	♀				2 weeks after diphtheria, paralysis of the pharynx and larynx, began to cough	10 days?	
Buzzard, E F Brain 25 453, 1905	Followed myasthenia gravis	48	♂	Collapse of base of left lower lobe, bronchi not de- scribed			Choking fits, dyspnea be- fore death		
Pasteur, W (cont'd) Lancet 2: 131, 1908 'Brandschaw lecture'	Case 10 mitral regurgi- tation, failure of right side of the heart	48	♂	Partial collapse of both lower lobes no bronchial obstruc- tion			Dyspnea, cyanosis, no dul- ness	?	
	Case 11 posterior part of right upper and middle lobe right lower lobe, left lower lobe almost airless followed operation and general periton- itis	49	♀	General peritonitis, right pleura 3 oz thin pus	Abdominal hyster- ectomy		4 days after operation, "pneumonia", on sixth day after operation, dysp- nea cyanosis, orthopnea temperature, 103 pulse rate, 144, respiration, 44	24 hours	
	Case 12 hour glass stomach with chronic ulcer small curvature	47	♀	Collapse of left lower lobe, except apex gastric ulcer	Too ill for opera- tion		'Agonizing gastralgia' on admission dyspnea tem- perature 101	Death in 2 days	

The same phenomena were produced in all our experiments. The diaphragm is always higher on the side on which atelectasis has occurred than on the sound side.

2 The most important part of our experimental work has been directed to the study of the obstruction of the bronchus and its results. First of all, we tried to find a way by which it would be possible to follow the successive stages of atelectasis by direct vision. We tried the transparent thoracic window without great success using cats for the experiments. The thoracic cavity was opened wide and a plate of

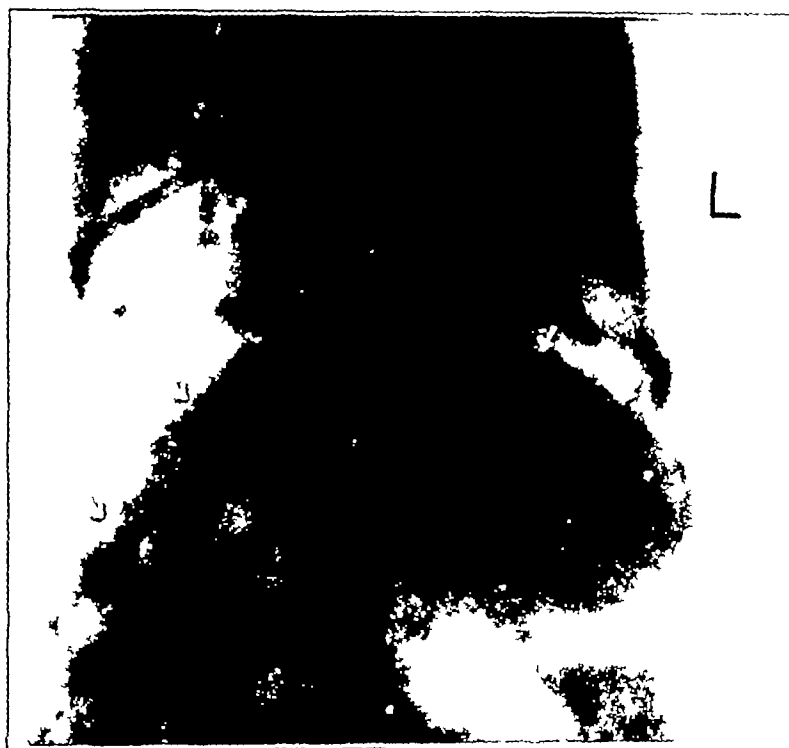


Fig. 5—Roentgenogram taken one half hour after plating of chest performed on the left side. The left side of the diaphragm is higher than right.

celluloid was shaped so as to occlude the opening of the pleural cavity to avoid desiccation of the lung. A bronchus was then exposed by bronchoscopic introduction of our balloon. The impossibility of turning the celluloid in good position for several hours was demonstrated by our experiment, obliged us to search for another method.

We thus adopted our "vacuum box" (fig. 8) of celluloid under our direction. This is composed of a rectangular box measuring 32½ inches (83.17 cm.) in length, 24 inches (60.96 cm.) in width and 12 inches (30.48 cm.) in height. A sleeve of celluloid at the top which runs in a groove in the upper part of the box is

# Statistics—Continued

Writer	Complication or Forerunner, Location of Collapse	Age	Sex	Deaths and Conditions Found Postmortem	Operation, Anesthetic	Onset, Symptoms	Duration	Treatment
Pasteur, W 1080, 1910 "Middlesex report"	Case 1 right lower lobe	23	♂		Left inguinal her niotomy, gas ether chloroform	24 hours after operation, dyspnea, pain in right side of chest, cyanosis, dextro cardia, temperature, 103 4 days after operation, pain and "tightness" in lower right side of chest	16 days	Oxygen
	Case 2 right lower lobe	37	♂		Drainage of right inguinal abscess, very painful, an- esthetic? Left pyosalpinge- ctomy followed by much pain, anesthetic?	4 days after operation, pain in left chest, cyanosis, tion of small dyspnea, gradual onset, pulse amounts vel temperature, 103, pulse amounts vel rate, 120, respiration, 40	11 days	
	Case 3 left lower lobe	24	♀			4 days after operation, pain expectora in left chest, cyanosis, tion of small dyspnea, gradual onset, pulse amounts vel temperature, 103, pulse amounts vel rate, 120, respiration, 40	8 days	Brandy
	Case 4 right middle and lower lobes	45	♀		Cholecystectomy, gas-ether chloro form	4 days after operation, tem- perature, 102, pulse rate, up 2 ounces cyanosis, 140, respiration, 40 sputum After fifth day, coughed thick green sputum 24 hours previously	7 days	Brandy, strychnine, oxygen
	Case 5 chronic cardiac disease, right lower lobe	49	♀		Cholecystostomy	2 days after operation, re- current attacks of heart failure, cyanosis, dyspnea, green thick sputum temperature, 100, pulse rate 114, cyanosis, dyspnea, cough 4 weeks after diphtheria, cough, dyspnea after operation, 24 hours after operation, tem perature, 102, pulse rate, 130	5 days	
Pasteur, W Surg 1 587, 1913 1914	Case 1 diphtheria, right lung		♂		Left inguinal her niotomy, gas ether-chloroform	72 hours after operation, dyspnea, cyanosis, temper- ature, 103, pulse rate, 120, respiration, 40, mucopuru lent sputum 48 hours after operation, pain in right side of chest, temperature, 102.6, pulse rate, 120, respiration, 26-32	28 days?	
	Case 2 diphtheria, both upper lobes	6	♀			4 days after operation, pulse rate, 120, respiration, 40 dyspnea, cyanosis, pulse rate, 120, respiration, 40 slight cough	12 hours	
	Case 3 right lung	23	♂		Left pyosalpingec tomy, anesthetic ?	48 hours after operation, pulse rate, 130, respira- tion, 24 30	4 days	
	Case 4 left lower lobe		♀		Subtotal hysterec tomy, chloro form	48 hours after operation, pulse rate, 130, respira- tion, 24 30	3 days	
	Case 5 chronic bron chitis preceding, right lung		♀		Cholecystectomy gas-ether-chloro form	4 days after operation, pulse rate, 120, respiration, 40 dyspnea, cyanosis, pulse rate, 120, respiration, 40 slight cough	21 hours	
	Case 6 right lower lobe	45	♀		Appendectomy gas ether, much mucus	48 hours after operation, pulse rate, 130, respira- tion, 24 30	49 hours	
	Case 7 right lung	12	♂		Appendec tomy		30 hours	
	Case 8 Left lung	23	♀					

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Statistics—Continued

Writer	Complication or Forerunner, Location of Collapse	Age	Sex†	Deaths and Conditions Found Postmortem	Operation, Anesthetic	Onset, Symptoms	Duration	Treatment
Scholtz C J M J S Africa 16 202, 1921	Right lower lobe	37	♂		Left inguinal herniotomy, nitrous oxide-ether	2½ hours pain, cyanosis	8 days	
Eccles, M W Lond M J vol 18					Lumbar nephrectomy			
St Bartholomew Hosp J 1914	Injury to rectum by iron spike	9	♂		Repair of rectum	2½ hours	24 hours	
Serlanger, F A C Surg, Gynec Obst 32:486, 1921	Case 1 right lower lobe	34	♂		Left inguinal herniotomy	24 hours, orthopnea, cough	15 days	
	Case 2 left lower lobe		♂		Chronic appendectomy	3 days, dyspnea, temperature, 102.2, pulse rate, 120, respiration, 30	24 hours after coughing up blood stained mucus	
	Case 3 left lower lobe		♂		Strangulated right inguinal herniotomy	24 hours, pain, dyspnea, temperature, 101, pulse rate, 120, respiration, 36	Recovery 24 hours after sudden coughing and drawing long breath	Blowing exercises
	Case 4 right complete		♂		Right inguinal herniotomy	13 days, temperature, 101, pulse rate, 108, respiration, 28, no distress	4 days	
	Case 5 coughing before operation, right lower lobe complete collapse of lung 24 hours later		♂		Right inguinal herniotomy	2½ hours, temperature, 100, pulse rate, 112, respiration, 36	27 days?	Blowing exercises
	Case 6 right lower lobe		♂		Subacute appendectomy	48 hours temperature, 101, pulse rate, 120, respiration, 40, dyspnea, cough	9 days	Blowing exercises
	Case 7 left lower lobe		♂		Hemorrhoidectomy	24 hours, cough, mucus, temperature, 100, respiration, 28	10 days	
Elwyn, H J A M A 79:2151, 1922	Case 12 right and left lower lobes		♀	Collapse of lower part of both lower lobes	Panhysterectomy, salpingo oophorectomy	48 hours	6 days	
	Case 13 right and left lower lobes		♀	Collapse of right and left lower lobes	Hysterectomy, bilateral salpingo oophorectomy, nitrous oxide	24 hours, diminished breathing, cough	5 days	
	Case 14 streptococcus bacteremia following operation, right lower lobe		♀	Collapse of right lower lobe	Left axillary cellulitis, nitrous oxide oxygen	Same day?	2 days	
	Case 15 left lower lobe				Cholecystectomy	2½ hours, rise in temperature	48 hours	
Ilkyn Girsdanaky I A M A 79:718, 1922	Complete collapse of right lung	14	♂		For stab wound in the epigastrium to left midline	24 hours, cough mucopurulent sputum temperature, 101 dyspnea cyanosis	13 days	

6 cm of water, with from eighteen to twenty revolutions a minute. This proved sufficient to keep the animal alive for several hours (up to six hours in dog 214 when the suction was cut off by accident while the heart was beating regularly and strongly and twelve and a half hours in dog 224). When the animal was thus placed and the intratracheal tube withdrawn, it breathed normally by mouth exactly as if the intrapleural pressure had not been disturbed. Curiously enough with a rate of eighteen revolutions a minute of the valve, dog 214 had real respiratory movements of its thoracic walls at one-half the rate of the revolutions of the valve. When the rate of the valve was increased, the respiratory movements slowed down. It was thus possible to reach at least a temporary equalization of the two rates. After regulation of the respiration the bronchoscope was introduced and a bronchus blocked.

**EXPERIMENT 3 (dog 218)**—A white male poodle weighing 7.7 Kg. was used. Iso-amyl-ethyl barbituric acid, 60 mg. per kilogram of weight was injected into the peritoneum. Anesthesia was complete in fifteen minutes.

March 10, 1927, 10 25 a. m. Intratracheal insufflation was established. The thoracic cavity was opened by midsternal section (Balfour retractor). The animal was placed in the negative pressure box and the collar fastened around the neck. The cover was replaced and the box tested air tight. The box was connected with the rotating valve and regulated to eighteen revolutions a minute and relative pressure oscillations between 3 and 7 cm. of water. The insufflation was discontinued. The lungs dilated regularly in synchronism with the revolution of the vacuum oscillations, but the animal made independent respiratory movements from time to time.

12 05 p. m. A balloon was introduced through the bronchoscope into the inferior right lobe bronchus and blown up with 5 cc. of water, a little below the lobe.

12 15 The lobe shrank to half its size and was yellowish. Unlike the rest of the lung, it did not expand during inspiration.

12 30 The condition was the same. The right lung was almost entirely collapsed. The lower lobe was bluish. The heart beats were strong and regular.

12 45 The lobe became darker and the size of the heart appeared to increase. The vacuum was purposely broken for a few seconds.

1 30 The inferior lobe was markedly blue and dark. The heart appeared on its surface. The vacuum was purposely broken for a few seconds. The other lobes became completely dilated. The collapsed lobe showed that the obstruction was good.

2 05 The heart gradually stopped beating. After the heart was removed into the heart it was revived for a few moments. The lobe was still collapsed.

**Autopsy**—The lower right lobe was much smaller than the rest of the lung and was one third of the normal size. The trachea was completely without air but a piece of the inferior vena cava was visible. The other lobes floated readily on the surface.

**EXPERIMENT 4 (dog 214)**—This experiment was similar to the one on dog 218 with the difference that the vacuum was not broken. It was completely as possible with a heart beating. The vacuum was broken under the borders of the wound. Water was poured over the wound. The desiccation was complete.

# Statistics—Continued

Writer	Complication or Forerunner, Location of Collapse	Age	Sex	Deaths and Conditions Found Postmortem	Operation, Anesthetic	Onset, Symptoms	Duration	Treatment
Ritvo, M. Am J Roentgenol 11 337, 1924	Collapse of right lung	23	♂		Relief of postoperative appendiceal adhesions, gas-ether	24 hours after operation dyspnea, "tightness" of the chest, thin yellow sputum, temperature, 102, pulse rate, 103, respiration, 30	Improved 6th day, recovered 8th day after operation	
Holmes G W Am J Roentgenol 11 509, 1924	Case 1 collapse of right lower lobe ?	20	♀		Left oophorectomy, right salpingo oophorectomy gas-ether	30 hours after operation, dyspnea rise in temperature, pulse rate and respiration small amount of purulent sputum	24 hours	
	Case 2 complete collapse of right lung	14	♂		Left indirect inguinal hernia, procain hydrochloride	48 hours after operation dyspnea, dry cough, pain in right side of chest	8 days	
	Case 3 chronic "smokers' cough," right lower lobe	19	♂		Subacute appendectomy, ether	48 hours after operation chill, cough, dyspnea, cyanosis temperature 103, respiration, 48	8 days+	
	Case 4 acute upper respiratory infection 10 days before admission complete collapse of right lung	40	♂		Bilateral herniotomy epidural anesthesia	1½ hours after operation, cough, purulent sputum, no pain no temperature, 102	Several days' after operation	
Abt I V Am J Dis Child 10 : 347, 1925	Right lower lobe, collapse complicated by pneumonia, right upper lobe ? on fourth day of collapse	10	♂		Appendectomy for gangrenous appendix, ether	48 hours after operation, dyspnea, cyanosis, painful cough, right side of chest immobile, interspaces widened	12 days	Dyspnea relieved by 1/12 grain morphine
Ice W F Bull N Y Clin Lab 9, 1925	Case 1 had bronchitis on admission, collapse of right lung	14	♂		For perforated appendix with abscess gas oxygen	5 days after operation, cough, thick green sputum cyanosis temperature rose 3 degrees, pulse rate, 152 respiration, 62, pain in right side of chest, right side of chest retracted	8 days during which increasing quantities of thick green sputum	
	Case 2 bronchitis and cough on admission pregnancy collapse of right and left lower lobes	18	♀	Local peritonitis, diaphragm right third space, left fifth to left lobular collapse of lower part of right and left lower lobes main bronchi and bronchioles filled with thick mucus	Cesarean section	3 days after operation	2 days	

5 00 The heart beat was strong, the rate moderate, the respiration rate was 32 and the vacuum rate, 16. The right lower lobe was bluish and well hidden behind the heart, close to the vertebral column.

6 00 When the clamps were removed and the chest opened, the animal made vigorous movements of the chest, which made it extremely difficult to keep the thorax open. The chest was quickly clamped and the cover of the box tightly sealed. The heart beat was strong, and the dog breathed well.

7 00 The respiration rate was 32, the vacuum rate, 16. The right lower lobe was small and was seen with the greatest difficulty by retracting the heart to the left.

8 00 A slight amount of ether was administered by the bronchoscope. The left lobes were prominent especially the lower lobe. The right lower lobe was the same as before. The vacuum rate was 18, respiration in the vacuum box was 22, respiration without the vacuum was 28, the chest being clamped.

9 00 The animal struggled violently when the chest was opened. Further marked changes were not seen. The anesthesia was taken well.

10 00 The manometer read 0 to 2.

12 00 The dog was in good condition and breathed well. There were no more changes than at the previous examination.

March 22 1 20 p. m. A sufficient amount of ether was administered under slight pressure. Changes were not noted.

1 45 The vacuum apparatus went out of order, but the animal breathed well with the chest clamped. The manometer read 0 to 2.

2 30 The animal died.

*Autopsy*—The trachea was clamped. The clamps were removed from the chest. The appearance was typical of massive atelectasis. The heart seemed to be to the right, the right side of the diaphragm was rather cupped and high. The left lobes were prominent and clearly seen, although one had to push the heart to the left to see the right lower and accessory lobes, which were shrunk and of a livid hue. The right lower lobe was affected in its lower two-thirds. The affected lobes sank in water, were airless and firm.

Microscopic section of the affected lobes revealed complete atelectasis without complications.

These three experiments show clearly the gradual production of atelectasis by obstruction, the development of which we followed step by step. Atelectasis was not complete in the first two cases because the time was not sufficient, but it was complete in the third case, in which the lobe was filled with oxygen. It was difficult to keep the animal alive under these conditions, several animals died within from one to three hours after the beginning of the experiment. The same sequence of phenomena always presented itself. Although the observations made during these experiments were convincing, we believed that it was necessary to find out what happens when the lung is occluded under normal conditions when the pleural cavity is intact.

3 Obstruction of a main or secondary bronchus was carried out in thirty-three dogs, fluoroscopies were carried out and serial roentgenograms made, clinical evolution was closely followed, autopsies recorded and sections of the lung examined. In all our cases, we reproduced



Statistics—Continued

Writer	Complication or Forerunner, Location of Collapse	Age	Sex†	Deaths and Conditions Found Postmortem	Operation, Anesthetic	Onset, Symptoms	Duration	Treatment
Griffith, T P C M J & Record 123 103, 1926	Preceded by diarrhea 23 days ♀ vomiting and nasal (prema regurgitation, collapse ture) of right lung	60	♀			Slight cough and duskiness	7 days	
Gwyn, N B Internat Clin 130, 1926	Case 1 followed pneu monia of right lower lobe, collapse of right upper lobe Case 2 followed pneu monia of left lower lobe, collapse of left lower lobe Case 3 pneumonia of left base, collapse of left upper lobe Case 4 followed peri carditis with effusion, complete collapse of left lung Case 5 associated with lobular pneumonia, left upper and middle lobes Tuberculosis of left up per lobe preceded by collapse of right up per lobe	63	♀	Lobular pneumonia of the whole left lung and lower left lobe		Fifth day of pneumonia, dyspnea, cyanosis, dextro- cardia ?, roentgen ray confirmed, heart shifted to left ?, no distress Sudden, dyspnea, heart shifted to left	3-4 days 7 days 3 days Gradual clearing	500 cc of air injected into right pleural cavity, 2 days, 3 times a day
Gammans, H F Bos ton M & S J 104: 638, 1926	Case 1 complete col lapse of right lung Case 2 Case 3 Case 4 right complete collapse followed by right empyema Case 5 collapse compli cated by pneumonia in right upper lobe collapse of right mid dle and lower lobes Case 6 followed frac ture of the pelvis Case 7) mentioned Case 8) not described	18	♂		Appendectomy, ether Cholecystectomy, local anesthesia Appendectomy Salpingectomy bilateral, ether Salpingectomy, bilateral	Gradual, coughing, 24 ounces purulent sputum, hemoptysis, increase in temperature and respira tion, pain over right apex 49 hours after operation, dyspnea, cyanosis, cough, temperature, 102 60 hours cyanosis, tempera ture, 103 24 hours after operation, temperature, 100.2, cough, cyanosis, heart and medi astinum to the right, after right empyema the heart shifted to the left Onset ?, pneumonia ? third day, rusty sputum 12 hours after injury right middle and lower lobes large amount mucoid sputum	Markedly improved in 6 days 14 days 4 days 13 days 6 days+	

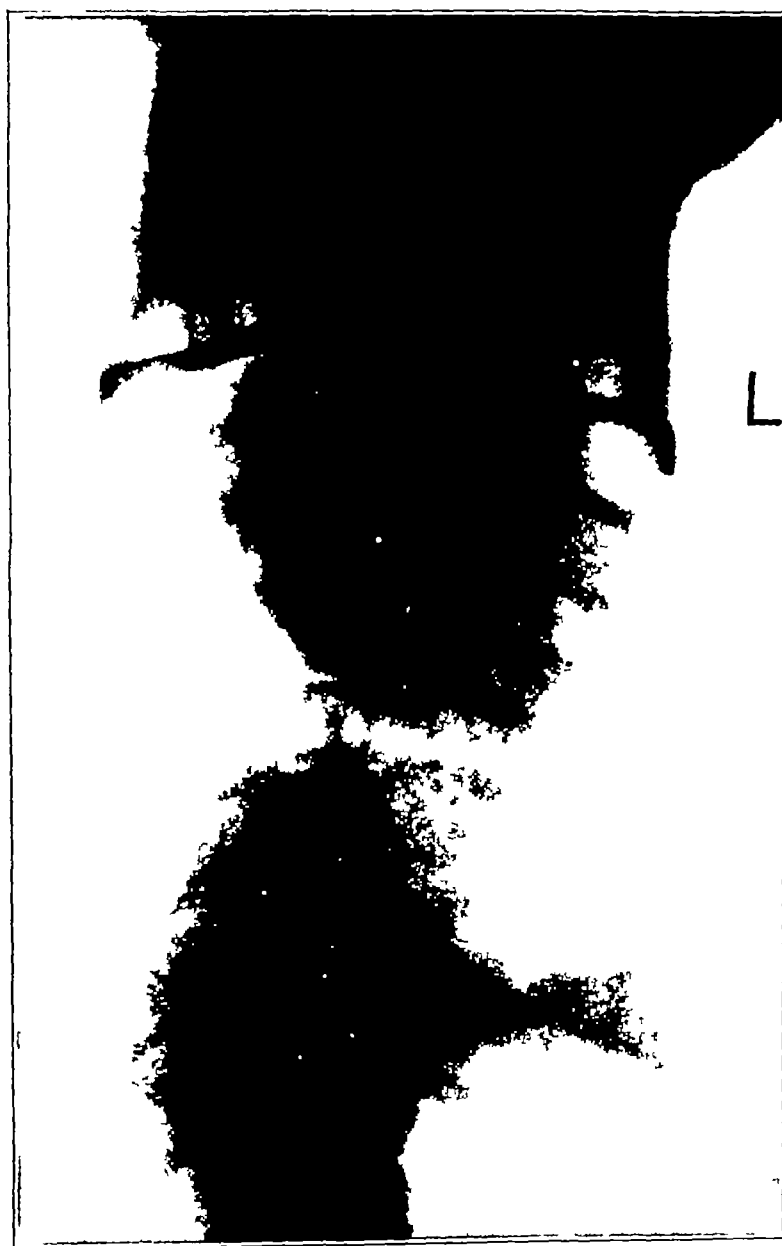


Fig 9 (dog 246) —Roentgenogram taken before blocking

## SUMMARY AND CONCLUSIONS

1 The determining cause of massive atelectasis of the lung (or patchy atelectasis), whether it is postoperative, spontaneous or secondary to obstruction by a foreign body or to infection, producing bronchial exudate of membranes, is always a complete obstruction of a bronchus (main, secondary or small) or compression of the lung (by effusion, pneumothorax, etc.) which abolishes the effects of the intrapleural negative pressure

2 The term "collapse" may lead to confusion because it does not always signify "airlessness," which is meant when the term "atelectasis" is used. Apneumatoxis would be an even more adequate term than atelectasis

3 The obstruction of a bronchus in postoperative cases is due to a plugging by mucus, which may be present at autopsy or which may have been expelled before death. It is possible that "plugging of a bronchus" may be effected by thin secretion or exudation occluding the lumen of a bronchus, so that the word "plug" must probably not be taken too literally. This interesting point is being given further study

4 As an aid to the accumulation of mucus, there are all the causes or factors which diminish respiratory movements and cough, namely, pain, paralysis of the respiratory muscles (intercostal, diaphragm) reflex respiratory inhibition from whatever cause, general cachexia, recumbency or narcotics

5 Spastic contraction of the bronchial muscle does not produce apneumatoxis, but it does produce emphysema

6 The existence of so-called "angioneurotic edema" of the lung has never been proved, clinically or experimentally. In the cases of acute anaphylactic shock in the guinea-pig, emphysema and not "collapse" is produced even when edema occurs (Hoover)

7 Atelectasis may predispose to infection by fixation in the parenchyma of the lung of septic emboli or microbes present in the circulating blood. This suggests the usefulness of the investigation of lobar pneumonia in possible relation to obstructive atelectasis because this could explain the anatomic lobar disposition of the disease in relation to the obstruction of a bronchus by (1) the pneumonic sputum which is so viscid and tenacious and (2) the diminished force of expectoration

8 From the foregoing considerations a definite therapeutic conclusion may be drawn. When simple methods, such as shaking or changing the position of the patient, are not quickly successful, the obstructing agent must be removed by bronchoscopy with aspiration or extraction in order to hasten recovery and to avoid further septic complications, such as bronchopneumonia, pneumonia or abscess. Artificial pneumothorax, as advocated by Elliot and Dingley, may be a palliative but is not a therapeutic measure

The possibility of establishing atelectasis of the lung with an intact thorax having been demonstrated, we continued our investigation further. The problems to which we tried to find the solution were

- 1 The rapidity of the establishment of atelectasis when the lung is filled with oxygen before the obstruction
- 2 The complications of atelectasis



Fig 11 (dog 246) —The animal died fifteen hours after blocking. Roentgenogram was taken six hours after death. The heart is greatly dilated, no iodized oil in the left lung, right diaphragm higher than during life (fig 10)

- 3 The result of the extraction of the obstructing balloon in the complicated cases

- 4 The relation between atelectasis (apneumatoxis) and localization of the infection in cases of bacteremia

- 5 Pathologic processes in atelectasis obtained by obstruction and the gross and microscopic complications

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105 F, recovery may occur, if the balloon is extracted and the pus contained in the affected bronchus aspirated. Recovery is impossible only in extremely severe cases, when the animal is moribund.

The time of the development of infectious complications is variable. It varied from twenty-four hours to six days in our dogs. Complications seem inevitable when the occlusion remains complete for more than seventy-two hours. We often recorded death occurring before the fourth day, probably due to heart failure or hypertoxic infection.



Fig. 13 (dog 255)—Roentgenogram taken five days after blocking, only the right median lobe is slightly hazy, balloon is less inflated.

Death occurred immediately only in rare cases in which the balloon, displaced from a main bronchus, occluded the trachea and killed the animal by asphyxia.

4 The relation between atelectasis and the fixation in the lung of circulating microbes is one of the most interesting features of this postoperative complication. Cutler and his associates, Scott, Elwyn and others, especially Karsen (Scott), believed that apneumotosis favors the development of bronchopneumonia, and, more rarely, pneumonia and

## KOHLER'S DISEASE \*

LEONARD W ELY, M D

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Kohler's disease is a peculiar condition in which the tarsal navicular bone is abnormal in shape, size and density. It was first described by Kohler of Wiesbaden in 1908. It affects boys more often than girls in the proportion of about two to one. The age limits are from 1 to 10 years, the great majority of cases occurring in patients between the ages of 3 and 7. The disease is characterized by pain which is made worse by exercise. Sensitiveness is also present over the navicular bone, possibly accompanied by redness and swelling. The patient limps, and may walk on the lateral border of his foot. The symptoms persist for a longer or shorter time, and then disappear. Complete recovery always takes place with any treatment.

The diagnosis is made with the roentgen rays. The bone nucleus of the navicular bone is usually narrow, that is, the distance from the proximal to the distal border is diminished, but the gap between it and the talus and that between it and the cuneiform bone indicate the presence of cartilage. The bone itself is usually irregular in shape, and irregular and dense in structure, so dense that the usual architecture cannot be outlined. On the other hand, the bone nucleus is seen occasionally as a faint irregular area, much smaller than that on the other foot.

The cause of Kohler's disease has never been established. Operations have been rare, one or two surgeons have reported positive cultures, but their reports are not conclusive. The condition has been ascribed to injury, fracture and obscure infection. Some recent writers consider the condition similar to Legg's disease and to Osgood-Schlatter's disease. In my book, "Inflammation in Bones and Joints," published in 1923, I classified the disease with these and with the true joint mouse found in adolescence in the medial condyle of the femur, and ascribed them all to an error in the development of the bone nucleus. Each condition occurs in boys predominately, at a certain age, and has a characteristic roentgen-ray appearance.

### REPORT OF CASES

CASE 1—A boy, aged  $4\frac{1}{2}$  years, complained of pain in his right foot. He limped at times. The mother noticed that he turned his foot out when he walked but she had never noticed any swelling. The foot was in slight eversion. All motions were free. A sensitive prominence was present over the navicular bone. Roentgen-ray examinations showed a dense, irregular navicular bone, "much

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\* From the Orthopaedic Clinic of the Stanford University Medical School

immediately after autopsy on dog 254. The nonatelectatic lung seems small because the clamp occluding the trachea was taken off by mistake before the photograph was taken. With the trachea clamped, the healthy lung was two times the size of the affected lung, which had a blackish color and a liver-like hue. The bronchi below the balloon were filled with mucus and often with pus. We have never found the bronchi below the obstruction free from secretion.



Fig. 15 (dog 251) —Roentgenogram taken forty-eight hours after injection of second doses of anaerobes, lungs clear, no abscess.

Adhesions of the pleura were found in one case, and foul effusion in the pleura was present in another. Patchy "collapse" was present in three cases in which the bronchioles were filled with pus. Bilateral pleurisy was noticed in two cases. We had no case of lobar pneumonia, although we had several in which edematous or congested lungs with areas of alveoli filled with serum and leukocytes were suggestive of pneumonic consolidation (fig. 18).



the navicular was "compressed and markedly irregular" One week later, the boy returned to the clinic He walked without a limp His left navicular bone was slightly prominent, but it was not sensitive on pressure There are two other children in the family who are alive and well The patient had an indication of an old Harrison's groove and fairly marked knock knees, but no other signs of rickets Almost four years later, he was bribed to return to the clinic



Fig 3 (case 2) —Similar to figure 1, but with slightly greater irregularity of contour



Fig 4 (case 2) —Complete recovery symptomatically and structurally after almost four years, without treatment

for roentgen-ray examinations He had not had any further trouble with his foot Clinically, there was no sign of disease and no deformity except, perhaps, a minimal prominence of the navicular bone Roentgenograms showed two normal navicular bones

CASE 3—A boy, aged  $6\frac{1}{2}$  years, was brought to the clinic with a history of swelling in his left foot for two weeks Little pain was present at first, but it

experimental cases and the human cases reported in the literature. We have purposely tabulated the latter to facilitate their comparison. We found 118 cases described and 12 mentioned in the literature, making a total of 130 cases. These do not include cases of frank obstruction by a foreign body. The observations made in our conclusions are based on this similarity, and although they may appear



Fig 17 (dog 254) —Massive collapse of the right lung, the clamp occluding the trachea was accidentally removed before the photograph was taken. With the trachea clamped the healthy lung was twice the size of the affected one.

somewhat radical, we believe that they are backed by experimental and clinical proof. Above all, we think that a practical conclusion results from this study, namely, the importance in atelectasis of the removal of the occluding agent by bronchoscopy and aspiration, and the value of the therapeutic benefits that are obtained.



Fig 7 (case 3) —The left foot, shown in figure 5, three years later Complete recovery without treatment



Fig 8 (case 3) —The right foot shown in figure 6, three years later Complete recovery, without treatment



Fig 9 (case 4) —The navicular bone shows a rather dense cortex, similar to that in figure 1 Its smooth surface is not that of a diseased bone

The importance of bronchoscopic treatment and aspiration of secretion, exudate or membranes obstructing the lumen of a bronchus is apparent. Although the prognosis in this disease is generally good, one cannot know at the onset what its evolution, duration or complications will be. Therefore we cannot too strongly insist on the necessity of bronchoscopic treatment when shaking of the patient, change of position and other measures are without beneficial effect.

We suspect that under certain circumstances even fluids that are not very viscid may be able to "plug" a bronchus effectively, during our experiments, this question often occurred to us. The altogether

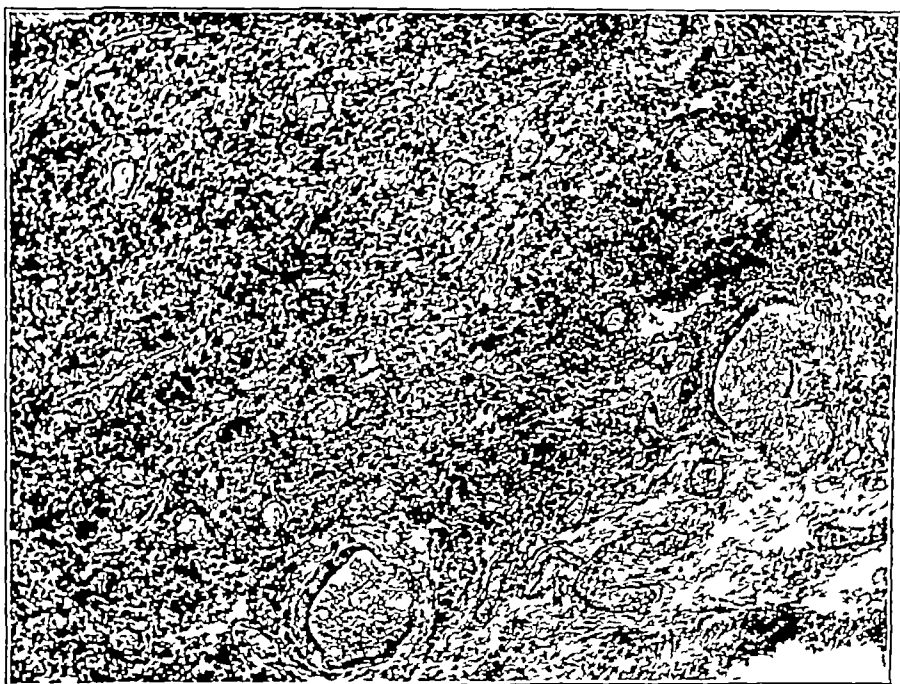


Fig. 20—Photomicrograph of fetal lung (atelectatic lung)

special physical conditions existing in the bronchial tree (because of its shape), the constant decrease in the velocity of the currents of air and of the sensibility of the bronchial mucosa to cough, producing stimuli as the alveoli are approached (as pointed out by Lincoln and Archibald) and other factors are subject to wide changes and modifications with possible alterations in the mucosa and in its ciliary epithelium. Congestion, alteration in the diameter of the bronchial lumen, action of capillarity and other factors may render possible an effective occlusion of a bronchus by fluids of only moderate viscosity. The bronchial tree cannot be likened to a system of glass or rubber tubes, nor the alveoli to a system of rubber balloons. These are interesting problems, which we are investigating.

in the region of the left navicular bone, with sensitiveness. Extremes of motion were painful. The roentgen rays showed the typical appearance of Kohler's disease. The foot was strapped with adhesive tape, and all symptoms had disappeared in about a month. Thirteen months later, the boy was again brought to the clinic complaining of pain in the right foot. The roentgenogram of the right

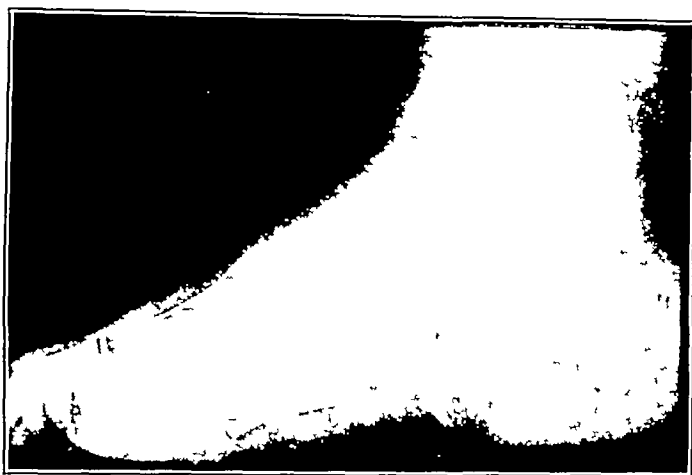


Fig 12 (case 5) —Roentgenogram taken four months after figure 11. The disease seems to have progressed, but the condition was said to have disappeared shortly afterward.



Fig 13 (case 6) —In this case there is simply marked irregularity of structure of the diminutive navicular bone, without the usual increase in density of Köhler's disease.

foot did not show any abnormalities, that of the left showed a solidification of the left navicular bone as compared with a roentgenogram taken the previous year, but some irregularity in structure was still present, although all symptoms were absent. Eighteen months later, or almost three years after the first visit,

Case 13 followed biliary colic—pyemia "right lower lobe except apex"	48	♀	Abcesses of liver (15 oz.), adhesions to diaphragm, right pleura had ¼ oz of bile stained fluid	No operation	?	7
Case 14 followed hydrochloric acid poisoning	30	♀	Esophagus stomach, duodenum badly damaged, no perforation general in complete collapse of both lungs		?	10 hours?
Case 1 diphtheria	1	♂	Collapse of right and left lower lobes and portion of right upper lobe bronchi not described		7 days after "paralysis of the diaphragm"	°
Case 2 diphtheria	2½	♂	Patchy areas, collapse of both lungs, slight general dilatation of bronchi which excluded pus on pressure		4 days after paralysis of the diaphragm	?
Case 3 diphtheria	3½	♀	sure Collapse of right lower lobe, scattered areas of collapse in left lung "some" bronchopneumonia		8 days after paralysis of the diaphragm	°
Case 4 diphtheria	4	♀	Collapse of right lower lobe and partial collapse of left lower lobe, emphysema of upper lobes		10 days after paralysis of the diaphragm was noticed	
Case 5 diphtheria	5	♀	Collapse of right lower and right upper lobes, except apex left lower lobe almost entirely collapsed		4 days after paralysis was noticed	
Case 6 diphtheria "cardiopulmonary crisis"	6	♂	Collapse ? not seen		"Well marked signs of asphyxia", no previous signs of respiratory paralysis	Death 2 days after paralysis of diaphragm
Case 7 diphtheria	1	♂	Small patches of collapse in posterior of both lungs, upper lobes, emphysema			Death 7 days after paralysis
Case 8 diphtheria	2½	♂	Collapse of entire posterior of right lobe and left posterior lobe and almost all of right lower lobe			
Case 9 diphtheria	4	♂			17 days after paralysis of the ribs was noticed dyspnea, temperature, 102	28 days

\* Fifty additional cases are reported by I. A. Masties, F. A. Splitler and F. P. McNamee. Arch Surg 15 155 (Aug) 1927.  
† In this table ♂ indicates male, ♀, female.

exist without causing any symptoms or physical signs. A close scrutiny of the roentgenograms often reveals greater or less abnormalities in the other bones of the feet. In spite of the great abnormality in structure, as shown by the roentgen rays, five patients recovered promptly with little or no treatment. The patient in case 5 wore a plaster for about six months, and then recovered. Not only does the patient recover promptly, but roentgen-ray examination shows that the apparently hopelessly damaged bone slowly develops and becomes normal in structure and in shape.

#### CONCLUSION

Kohler's disease is a developmental anomaly of the tarsal navicular bone accompanied by symptoms. Patients with this disease always recover spontaneously. As in Osgood-Schlatter's and in Legg's disease, the anomaly may exist without symptoms. The patient should be treated symptomatically.

Tidy, H. L., and Phil  
lips, E. Lancet I  
12/15, 1914

No previous operation  
nor injury, right  
lower lobe 20 ♂

Elliot and Dingley #  
Lancet I: 305 1914

Case 1 right lower lobe 31 ♂

Case 2 right lower lobe 23 ♂

Crymble, P. T. Brit J  
Surg 5: 363, 1917 1918

Case 6 perforating  
wound right thorax,  
right pyopneumo  
thorax, left middle  
and upper lobes

Case 9 perforating  
wound in right side of  
chest, possibly liver  
and diaphragm com  
plete collapse of left  
lung

Case 10 superficial  
wound in left side of  
chest collapse of  
right lower lobe

Case 11 superficial  
wound in left side of  
chest, complete col  
lapse of left lung

Case 12 perforating  
wound in left upper  
part of chest, col  
lapse of right upper  
lobe

All right collapse of  
which 6 contralateral  
and 1 homolateral to  
wound 10 cases men  
tioned not described  
Superficial wound in the  
skin, face right side  
of the back, one deep  
wound at angle of  
scapula, almost com  
plete collapse of left  
lung

Penetrating wound in  
line crest collapse of  
left lower lobe 22 ♂

Rose-Bradford Quart  
1919 J Med 12 127 1918

41 ♂

# Nine more cases mentioned  
† In this table ♂ indicates male, ♀, female

Double inguinal  
hemiotomy,  
chloroform

Gangrenous appen  
dectomy  
valvulo-spinal an  
esthesia

Operation follow  
ed recovery from  
collapse

48 hours respiration, 40

3 (?) days after injury

11 days after injury

3 days

In "a few days" after in  
jury retraction of supe  
rior mediastinum to right

2 days after wound no sub  
jective signs slight cough

3 days after onset

6 days after injury, mucoid  
cough

14 days ?

Sudden pain in right side of  
chest dyspnea, cyanosis,  
sweating vomiting

5 ? days after operation,  
cyanosis, pain in sternum,  
mucopurulent sputum

46 hours respiration, 61  
pulse rate, 116, respira  
tion, 40

4 days,  
mucopuru  
lent sputum

11 days

9 days

Oxygen

6-7 days?

14 days

13 days+

16 days

14 days

15 days



He had not any sickness for forty years. At the age of 14, he had suffered with so-called typhoid pneumonia. There was no history of abdominal disorder. The weight had been the same for several years.

*Physical Examination*—The patient was large and moderately obese. There was no hernia. There was marked rigidity of the upper two thirds of the right side of the abdomen which extended somewhat posteriorly. Tenderness was exquisite over this area. A mass could not be palpated, probably owing to the rigidity, tenderness and obesity. The temperature was 99.6 F, the pulse rate, 100 and the white blood cell count, 17,000. Otherwise the results of the examination were negative.

*Operation*—Ethylene and ether anesthesia was given. An incision was made near the midline in the upper part of the abdomen. There was a quantity of free clear fluid in the peritoneal cavity. A large mass was seen at the right side of the midline, consisting of a large fat omentum. This was discolored bluish and red in areas. There was a complete twist to be seen at its base just below the stomach. The omentum was not attached to the transverse colon. The mass extended across the transverse colon for about 4 inches (10.16 cm) and lay beneath the hepatic flexure of the colon, where it was partially attached (fig 1) by recent fibrinous adhesions to the epiploic appendices. The surrounding tissues were edematous. There was no evident constriction of the transverse colon. The whole omentum was twisted and strangulated with hemorrhagic areas throughout. It was resected above the twisted region, which was somewhat smaller than the thick, fat distal mass. The base was completely twisted one and one-half turns. The appendix, which was bound down and not inflamed, was not removed.

The gallbladder, stomach and pancreas were normal.

*Pathologic Examination*—The specimen consisted of a firm mass of omental tissue, 11 cm wide and 2 cm thick. The anterior surface was smooth, lobulated, glistening, reddish yellow with darker streaks of red running between each lobulation. About one third of the middle of the posterior surface was lemon yellow. The remainder was like the anterior surface. The cut edge was dark red and contained congested blood vessels, which with the omental tissue surrounding the base had twisted one and one-half times. Surfaces made by cross-cutting had a core of dark brown, distinctly lobulated, slightly softer tissue than the covering. This was surrounded by reddish-yellow, firm tissue 2 mm thick in the anterior surface, 5 mm in the posterior and about 15 mm from the sides.

On one side of the omentum was a small tag or process the pedicle of which had also twisted (fig 1).

Microscopic examination of a section showed many fat lobules in which the fat cells were separated by blood. The lymphatics were filled with polymorphonuclear leukocytes and a few lymphocytes. In the connective tissue, likewise, were many polymorphonuclears.

*Postoperative Course*—There was an acute dilatation of the stomach on the second day, which was severe and lasted three days in spite of repeated aspirations. On the eleventh day, bronchopneumonia developed in the right base, running an atypical course and possibly being embolic in origin. It lasted about six days. The patient was in the hospital for twenty-six days and made a complete recovery.

One year later he was entirely free from complaints and doing his usual work.

Complicating pneumo  
nia (11 cases)  
Case 8 right lower lobe 30 ♂

Case 9 right and left  
base 28 ♂

Case 10 right base 21 ♂

Case 11 asthmatic pa  
tient, collapse of left  
base complicated by  
pneumonia, 4th day 13 ♂

Case 1 left lower lobe 38 ♀

Case 2 right lower lobe 49 ♂

Case 3 right and left  
lower lobes 48 ♂

Case 1 right lower lobe 32 ♂

Case 2 right lower lobe 35 ♂

Right lower lobe com  
plicated by purulent  
pneumonia in left  
upper lobe  
Case 1 complete col  
lapse of right lung ♂

Case 2 complete col  
lapse of right lung 22 ♂

Case 3 complete col  
lapse of right lung 25 ♂

Case 4 left lower lobe 24 ♂

Hirschbroeck F J  
Am J M Sc 164:  
268, 1922

Phywn H J A M A  
S 384, 1924

Lee W F Ann Surg  
77: 518, 1924

Laopold S S Am J  
M Sc 167: 421, 1924

Gangrenous, ap pendectomy in trous oxide ether	20 hours after operation cough, thick, blood stained sputum, pain in chest, temperature, 102° pulse rate, 120, respiration, 30	4 days
Left inguinal her niotomy, in trous oxide-ether	10 hours after operation, cough, dyspnea, cyanosis, frothy expectoration, no dextrocardia, temperature, 102°, pulse rate, 160, respi- ration 40	4 days
Gangrenous, ap pendectomy gas-ether	15 hours after operation, cough dyspnea, expecto- ration, temperature, 100, pulse rate, 160, respira- tion 30	4 days
Gangrenous ap- pendectomy ap- local anesthesia, gas-oxygen	12 hours after operation, pain in left chest, orthop- nea, dyspnea, cough, temperature, 104° pulse rate, 140, respiration, 40	3 days temp 100, pulse 120, resp 30, fourth day, temp 102° = pneumonia, well 9 days later 4 days?
Ovarian cyst ap- pendectomy, laparotomy	48 hours, temperature, 101, pulse rate, 130	4 days?
Acute appendec- tomy	24 hours, temperature, 102, pulse rate 110 dyspnea	3 days
Appendectomy posterior gastro- enterostomy	6 days, dyspnea, no dis- placement of the heart	48 hours
Left indirect in- guinal herniot- omy, gas ether	24 hours, cough, pain	14 days
Colectomy for car- cinoma of the ileocecal junce- tion, gas oxygen	24 hours, temperature, 102	8 days + +
Strangulated fe- moral hernia (side) local an- esthesia	72 hours	7 days
Ventral hernia, ether	24 hours, sudden, dyspnea, cyanosis increase in tem- perature, pulse rate and respiration	5 days + +
Left inguinal her- niotomy, ether, 6 ounces	3 days sudden dyspnea, cyanosis increase in tem- perature pulse rate and respiration	5 days ?
Right inguinal her- niotomy, ether 8 ounces	2 days sudden, dyspnea, cyanosis, increase in tem- perature, pulse rate and respiration	5 days? recurrent collapse and 2 days?
Left inguinal her- niotomy	24 hours sudden, symptoms as above	

† In this table ♂ indicates male ♀ female

*Physical Examination*—The patient was moderately obese and looked anxious. There was no hernia. The abdomen was prominent, due to obesity. There was exquisite tenderness over the right lower quadrant. This extended upward, somewhat along the region of the ascending colon and laterally. Muscle spasm was marked but rigidity was not definite. A mass could not be felt, but palpation was not satisfactory.

The temperature was 99.4 F, the pulse rate, 92, leukocytes, 12,000. Otherwise results of the examination were negative.

*Operation*—Ethylene anesthesia was given. A muscle splitting incision was made. The peritoneum was thickened and edematous. There was considerable clear fluid in the peritoneal cavity. The appendix, which was congested and felt to contain a fecalith, was removed. The surrounding structures were also con-



Fig 2 (case 2)—Strangulation of the distal half of the obese omentum by torsion following unusual physical exertion. The narrow pedicle is apparently of long standing.

gested. The changes in the appendix were not thought sufficient to explain the surrounding edema and congestion. The incision was therefore enlarged and the abdomen explored. A mass the size of a kidney and resembling it in color could be felt and seen just above the incision. This was easily separated from several edematous epiploic appendices, when it was seen to be a strangulated hemorrhagic omentum. The omentum was narrowed near its middle portion by a narrow pedicle which was twisted one and one-half turns (fig 2). It was resected above the pedicle, and the raw end was closed with transfixion sutures. The abdominal viscera were otherwise normal on exploration.

*Pathologic Examination*—Gross. The strangulated mass of omentum measured 14 cm in length. It varied in width up to 5 cm and in thickness up to 3 cm. The pedicle was 4 mm in diameter. The one and one-half complete twists tended to return after untwisting. Distal to this point the omentum was

Case	3	collapse of right lower lobe lob- ular collapse of right middle lobe	21	♀	General thick mucopus in right middle and lower bronchi col- lapse of lower third of lower lobe scat- tered areas on pos- terior of right mid- dle and lower lobes Carcinoma of head and pancreas liver large (metastases) right diaphragm high and tense mu- cus in bronchi not excessive	Appendectomy (peritonitis)	Death 6 days after operation
Jackson, C and Lee, W F Ann Surg 32 364 1925	Case 4	carcinoma of the head and pan- creas, collapse of both lower lobes	18	♂	Carcinoma of esopha- gus just above cir- dia metastases to liver (3 <sup>rd</sup> normal) right diaphragm high and tense, right lower bronchus had a moderate amount of thick bloody mucus		?
	Carcinoma of the esophagus collapse of right lower lobe		47	♂		? with rise in temperature and signs, right lower bronchopneumonia	Death within 24 hours
	Case 1 collapse of right lung		11	♂		5 days after operation, cough thick green spu- tum for 5 days tempera- ture 105, pulse rate 152 respiration 52 3 days	42 days
	Case 2 partial collapse of right base and left base		18	♀	Collapse of left base and partial of right base, local periton- itis paralytic ileus hydro-ureter hydro- nephrosis, in thick mucopus in left lower bronchus	Gangrenous ap- pendectomy lo- calized abscess kansas-oxygen C'sarean section	6 hours, death
Scott W J M Arch Surg 10 73 1925	Case 37 collapse of right lung		18	♂		Cough 2 hours after opera- tion 13 hours pain in right side of chest dysp- nea not to be tempera- ture 102.4, pulse rate, 120, respiration 40 24 hours after operation middle lobe of right lung collapsed 48 hours total right lung collapsed tem- perature 101 pulse rate, 120, respiration 52 48 hours	48 hours recovery starts 7 days recovery complete 10 days
	Case 38 collapse of right lung		20	♂		Appendectomy upper explora- tory, ether, (cough and mu- cus during induc- tion) Appendectomy repair ventral hernia, ether	7 days, 1 day after coughed up 120 cc of blood 14 days+
	Case 39 chronic bron- chitis, 4 years col- lapse of right lung		19	♂		Appendectomy kansas, ether	
	Case 40 collapse of left lung,		26	♂		Appendectomy ether	

† In this table ♂ indicates male ♀ female

ETIOLOGY OF PURE TORSION OF THE OMENTUM WITHOUT  
HERNIA, ADHESIONS OR NEW GROWTHS

*Sex*—Eighteen cases of torsion were stated to be found in males, six in females

*Age*—The average age at which torsion occurred was 38 years, the youngest patient was 1 year of age, and the oldest, 63. Two cases occurred in the first two decades, seven in the third, four in the fourth, six in the fifth and sixth, and only one in the seventh.

*Factors Producing Torsion*—The Narrowing or Formation of a Pedicle on the Omentum. Payr believed that a narrow pedicle or bulbous tip predisposed to torsion, which resulted usually from hyperemia of the veins with rotation around the tense arteries. He produced spontaneous torsion of the omentum experimentally by the formation of gas cysts from 0.4 to 0.5 cm. in diameter, and also by the insertion of small pieces of cork and paraffin. Torsion was produced, he thought, by the shorter arteries acting as a mesentery which, following a hyperemia of the veins, produced a spiral out of the convex side. He demonstrated how torsion of a rubber tube occurred under similar conditions. He said that factors favoring torsion were similar in a distended appendix and might occur in any pedunculated organ.

Cunningham<sup>9</sup> described the omentum as usually lying more in the left hypochondrium with the left border extending over the descending colon and undergoing less motion than the right side, which frequently presents one or more processes. Anatomic variations in the blood vessels may predispose to a pedicle. Cowell<sup>10</sup> found that the blood supply of the omentum arose from the long epiploic branches of the right and the left gastro-epiploic arteries. These course over the transverse colon not between the anterior layers of the omentum, but in little peritoneal folds on mesenteries of their own. They form an arch at the lower border of the omentum. Posteriorly, a few branches from the middle colic artery reach the lower portion of the omentum.

The congenital formation of a pedicle should be considered in group 1, since adhesions are not present. Broca<sup>11</sup> has reported torsion in a young infant, and it also occurred once in infancy in group 1. Numerous anomalies of the omentum have been described. Draper and Johnson<sup>12</sup> emphasized the importance of congenital omental bands which, by roentgenologic examination, they demonstrated produced

9 Cunningham. Human Anatomy, quoted by Cowell.

10 Cowell, E. Abdominal Torsion of the Omentum, *Brit J Surg* 12: 738 (April) 1925.

11 Broca, quoted by Thevenard.

12 Draper and Johnson. The Pathologic Omentum, *J A M A* 88: 376 (Feb.) 1927.

Mason, R. L. Surg Clin N Amer 6:739, 1926	Collapse of left lung	18	♂	Bilateral inguinal hernia, gas ether	55 hours after operation, dyspnea, pain beneath xyphoid, cough, cyanosis, temperature, 102°, pulse rate, 120, respiration, 48	72 hours	Rolling from side to side
Singer, J. J. cited by Mason, R. L. Surg Clin N Amer 6:739 1926				Appendectomy			
Herrman, W. G. cited by Mason, R. L. Surg. Clin N Amer 6:739, 1926	Associated with pneumo thorax						Rolling from side to side
Kletz, N. Lancet 212 170, 1927	Followed acute menin gitis, collapse of right and left lower lobes	18	♂	Collapse of right and left lobes, lungs leathery, few ounces of fluid in both pleura, meningococci and streptococci in cerebral sulci	3 days after meningitis (dyspnea, "gripping" of chest, temperature, 101.4, pulse rate, 126 collapse of left lung 24 hours after right lung collapsed	24 hours	
Harrington, S. W., et al. Ann Surg 35, 152, 1927	Collapse of left lung	28	♂	For right hydro nephrosis, ether	24 hours, "burning" under sternum, pain in left side of chest, temperature, 102, pulse rate, 110, respira tion 28	15 minutes	Bronchoscopy, aspi ration, 300 cc thin serous secretion
Sante, L. R. J. A. M. A SS 1530, 1927	Case 1 injury of left hip, collapse of right lung	16	♂		24 hours after injury	Cleared up 3 minutes after rolling from left side to back (fluoroscopy)	Rolling from side to back (accidental)
	Case 2 collapse of left lung	30	♂	Kidney fixation (side?), ethylene- ether	7 days after operation temperature, 102.8, pain in chest	9 days	Rolling from side to side, plus cough
	Case 3 gunshot wound in abdomen, pelvis and left wrist col lapse of right lung	23	♂	Exploratory lap arotomy, drain age of subcuta neous tissues	4 days after operation dyspnea, pain in right side of chest and at um bilicus, temperature 102, respiration, 40	As above coughed up 5 cc of mucus (globular, gray, minutes after gumdrop")	
Bergamini, H. and Shep ard, L. A. Ann Surg 80 35 (July) 1927	Case 1, M. L. collapse of left lung	44	♀	Occurred near end of operation un der gas-oxygen ether, hysterec tomy, salpingo oophorectomy	Patient stopped breathing near end of operation	Artificial respiration stimulants	
	Case 2	69	♂	Laparotomy, gas oxygen ether, gas	Sudden, at end of opera tion	Artificial respiration stimulants	
Hearn, W. P., and Clerf L. H. Ann Surg 55, 54, 1927	Collapse of left lower lobe	8		Closure of gas trostomy fistula cough, much mu cus during anaes thesia	30 hours after operation, temperature 103.4, diag nosis made 64 hours after operation	23 days+, 6 aspira tions done, less secre tion each time	Bronchoscopy 8 hrs after diagnosis made, aspiration of thick, tenacious, yellow sputum from trachea and left bronchus

† In this table, ♂ indicates male, ♀ female

‡ Fracture of pelvis, onset 12 hours, duration 3 days

§ Fracture of spine and right ribs, recovery complete, cleared up shortly

While torsion may also develop from a number of causes it is evident that a narrow pedicle may exist for a long time before rotation occurs

**Obesity** Fat infiltration may predispose to torsion by development of a pedicle with a bulbous tip. It may also produce changes in the blood vessels leading to stasis or vascular tension. In the eight cases in group 1 in which general obesity of the patient was noted, there was little narrowing at the site of the torsion in seven, but in one the pedicle was small. In ten other cases, the strangulated portion of the omentum was described as a fat round mass.

Obesity of the omentum probably predisposes to torsion, since obesity was more marked in the cases in which there was no definite pedicle.

**Inflammation of the Omentum or Neighboring Viscera** Inflammation of the omentum or neighboring viscera may lead not only to pedicle formation, but may produce hyperemia. Acute or chronic inflammation may result in scars, constricting bands, adhesions with a second fixed point to the omentum or to incarceration in a hernial sac. Schoenholzer<sup>16</sup> stated that torsion of the omentum did not occur without previous inflammation. Skeel<sup>17</sup> reported chronic appendicitis as being present in eight of ten reviewed cases, and he thinks that this predisposed to torsion. Inflammation was probably not an important factor in group 1.

**Trauma or Pressure** An acute trauma of the omentum from either within or without the abdomen may produce torsion. In Eitel's patient, torsion resulted from chronic pressure of a box. My first patient fell on the upper part of his abdomen. Bazy<sup>18</sup> has suggested the pressure of intestinal peristalsis as exciting torsion. Pressure of an abdominal tumor might produce it, such as an ovarian cyst, or a pregnancy, as in Bubis's<sup>2</sup> case. Sudden contraction of the abdominal muscles as well as a blow applied with the muscles in relaxation have been noted. In Kraske's<sup>19</sup> case, torsion followed an operation in the Trendelenburg position. Taxis on a strangulated hernia has been noted by Lejars<sup>20</sup> and others.

**Heavy Work or Unusual Physical Exertion** Torsion followed heavy or unusual work in Mullen's<sup>21</sup> and in Eitel's<sup>8</sup> cases but the symptoms were slow in developing, usually the onset was of short dura-

16 Schoenholzer, quoted by Thevenard

17 Skeel, R. E. Intra-Abdominal Torsion of the Omentum Without Hernia, *Am J Obst* **56** 792, 1907

18 Bazy, quoted by Thevenard

19 Kraske, quoted by Aimes

20 Lejars. *Semaine méd* **27** 73, 1907

21 Mullen, T. F. Torsion of Great Omentum, *Surg Gynec Obst* **40** 635 (May) 1925

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cases The entire omentum was strangulated in 42 per cent, a portion of the omentum in 50 per cent and an accessory omentum in 8 per cent Where only a part was involved, it was noted that it was the distal half in five cases, the right free border in one, the right lower corner in one and the right half in the case that was associated with acute appendicitis The pedicle arose by a slender stalk of blood vessels on the free edge of the omentum in one and in an undesignated part in four instances In the two cases of accessory omentum, this arose from the transverse colon at the right of the main omentum

The size of the strangulated mass of omentum varied It was described as fat in 69 per cent of the cases In eleven instances in which measurements were reported, it averaged 12 by 8 by 3 cm in size It usually appeared dark red or purple and was frequently in a state of red infarction The veins were only occasionally reported distended The consistency was firm, almost as if it were frozen

Three stages of changes have been described in the omentum The first stage is congestion and venous stasis, the second, the most frequently noted, is extravasation of blood, infarct formation and thrombosis of blood vessel as in Kohlei's<sup>25</sup> case, and the third stage is necrosis Only in Simon's<sup>28</sup> and Lefebvre's<sup>29</sup> cases were gangrenous areas reported Areas of increased connective tissue formation with exudation of white blood cells and stasis were noted in Wiener's<sup>27</sup> and in my cases

The appendix was found acutely inflamed in Scudder's<sup>30</sup> case, slightly congested in two, thickened in one, containing a fecalith in one, obliterated in one and normal in eight other cases Congestion in the appendix could be excited by the torsion or vice versa, although there were no adhesions of the omentum to the appendix in group 1

Edema and thickening of the peritoneum were present over a large area near the strangulated omentum in my two cases, together with a marked hyperemia which also involved the abdominal muscles In a number of instances described, there was an agglutination with recent fibrinous adhesions of the omentum to the gallbladder the liver or the diaphragm or to portions of the intestine and the ascending colon The epiploic appendixes were edematous and loosely adherent to the omentum by fibrin in my two cases Baldwin<sup>31</sup> described a local peritonitis

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On physical examination, a palpable mass was noted in six cases and was absent in twelve. It was palpated in three cases in the right lower quadrant, once in the hypogastrium and once in the right upper quadrant. While the pain was to the right of the umbilicus in Riedel's first case, there was a mass in the left lower quadrant palpable by vaginal examination. In two instances, there was a subjective sensation of a mass.

Rigidity and muscle spasm were noted in twelve cases, the abdomen was boardlike in four cases. Rigidity was absent in Cullen's<sup>24</sup> and in Grove's<sup>36</sup> cases. Tenderness was noted in fourteen cases and was exquisite in eleven of them.

In one case (Lefebvre) with an acute onset, hyperesthesia was not noted. Diarrhea was noted in one case (Skeel), constipation was noted occasionally. The pulse rate varied from 72 to 130, averaging 96 in ten cases. The temperature varied from a subnormal to 101.5 F and averaged 99.6. The white blood count varied from 9,000 to 17,600 and averaged 14,000 in seven cases. There were 74 per cent of polymorphonuclears in one case.

#### DIAGNOSIS

The diagnosis of torsion of the omentum without hernia is difficult. It should be considered in an obese middle-aged man, with acute tenderness and an increasing cramplike pain in the right side of the abdomen, continuing for several days following some unusual or violent physical exertion, especially in the absence of nausea or vomiting. The exquisite tenderness which is out of proportion to the other symptoms, and cramp-like pains increased by movement, are the most characteristic symptoms. Rigidity and muscle spasm, although usually not marked, may prevent the palpation of a mass. The temperature and pulse rate are not high, and the white blood count is lower than might be expected from the symptoms. The presence of bloody abdominal fluid should make one think of torsion.

The preoperative diagnosis was acute appendicitis in eighteen cases, acute cholecystitis in three, internal hernia of the omentum in one and a hydatid cyst in one. The appendix in one instance was thought to be located high up and in another to be associated with an abscess.

#### PROGNOSIS

In group 1, death occurred once from pneumonia, six days after operation (Lefebvre) in a man, aged 55, with a pulse of 130 on entrance and complete necrosis of the omentum. A postoperative acute dilatation of the stomach and pneumonia occurred in one of my cases. In review-

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<sup>36</sup> Groves, W. R. Torsion of an Omental Tag, *M. J. Australia* 2:697 (Nov. 21) 1925.

compressed from before backward" The other navicular bone was normal The patient did not return to the clinic Four and one-half years later, he was persuaded to return for roentgen-ray examination He had not had much trouble since the previous visit, and had recovered completely No sign of the disease was present, and there was no deformity The roentgenograms showed normal navicular bones



Fig 1 (case 1) —Lateral view of foot Note the density of the bone, the irregularity of its structure, the comparative smoothness of its proximal and distal borders and the clear space between it and the cuboid and talus In a destructive disease of the bone, its structure would be rarefied, and its collapse would mean the approximation of the cuboid to the talus



Fig 2—The same foot as shown in figure 1, four and one-half years later showing restoration of function and structure without treatment

CASE 2—A boy, aged  $6\frac{1}{2}$  years, had had moderate pain in his left foot for five or six days He walked with a limp, and the foot had been swollen The swelling had decreased and the pain had disappeared Examination showed only a "typical case of Kohler's disease," whereby I am led to infer that the swelling and sensitiveness were present over the navicular The roentgen ray showed that

## SUMMARY

1 Torsion of the omentum may occur in the absence of hernia or any pathologic condition and without previous abdominal symptoms

2 There is almost always evidence of a preexisting pedicle, which may be congenital in origin

3 Obesity of the omentum is present in the majority of cases, and it is probably a frequent predisposing factor both in the formation of a pedicle and in the torsion

4 Hyperemia may be the usual exciting factor in torsion, although trauma or unusual physical exertion may initiate it

5 Prophylactic resection of a pedunculated omentum and freeing of adhesions is usually advisable

6 Early operative resection of the strangulated omentum should be performed

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had increased for the last three days before he came to the clinic. At first walking was difficult, but for the past three days it had been impossible. Pain was much worse when the patient attempted to use his foot. Examination showed swelling of the left foot, with increase in local temperature and tenderness over the navicular and the cuboid bones. The roentgen ray showed the characteristic changes of Kohler's disease. "The changes were not essentially different in one



Fig 5 (case 3) —Left foot, showing density and irregularity of the navicular bone. This was the painful foot

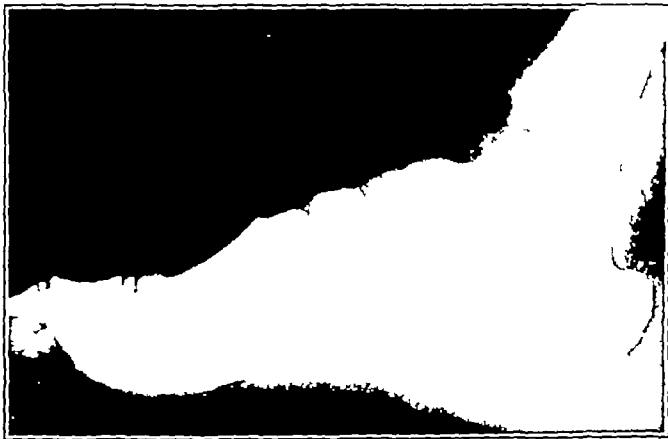


Fig 6 (case 3) —The right foot which was the foot without symptoms. The navicular bone is more abnormal than in the foot of which the patient complained, and appears to be developing from two nuclei

foot from those in the other. The left scaphoid outlines showed definitely that the scaphoid bone had collapsed." Anteroposterior roentgenograms showed also irregularity of development of the medial cuneiform and fifth metatarsal bones. The patient was sent to the hospital, and the foot was wrapped in cotton. Salicylates were administered. The pain at first was intense. After four days the foot was strapped, and the patient was discharged. He did not have any

months after the operation. Pathologic examination showed the tumor to consist of alveoli surrounded by smooth muscle bundles. The epithelial lining of the alveoli resembled that of the stomach mucosa and was single-layered. The alveoli did not open into ducts but formed closed cystic cavities. A connection between the alveoli of the tumor and the epithelium of the stomach was not demonstrable. Evidence of malignancy was not found.

In 1925, Stewart and Taylor<sup>3</sup> described four cases. One was found at autopsy, the other three at exploratory operations. In the three latter cases, the adenomyoma constituted the only abnormal observation. In one case in which gastric tabetic crises was later suspected, the patient was unrelieved. The two remaining patients complained of epigastric pain which came on several hours after meals and which was relieved by food. A roentgen-ray examination was performed on one of the patients, but a pathologic condition was not revealed. Both patients were relieved by operation. All of the tumors were small and located near the pyloric ring. Microscopically, they showed alveoli of the Brunner's gland type, alveoli of the pancreatic type and undifferentiated alveoli. All were surrounded by smooth muscle strands. Duct-like structures were also present.

#### REPORT OF A CASE

*History*—Miss E. J., a practical nurse, aged 36, entered the medical service of the University of California Hospital on March 1, 1926, with a complaint of vomiting and epigastric pain. Her family and past history were essentially negative. About five years before (January, 1921), she had had attacks of vomiting without nausea, followed by gnawing, nonradiating epigastric pain not related to meals and unrelieved by food or sodium bicarbonate. The vomited material had frequently contained fragments of food eaten one or two days previously, but never blood or coffee-ground material. Other gastro-intestinal symptoms, except belching, had been absent. The attacks had occurred several times a day at intervals of from a few days to several weeks. She had consulted a physician, who, after taking roentgenograms, made a diagnosis of "peptic ulcer." Dietary regimen had not given relief, a small duodenal ulcer about 1 inch from the pylorus had been found and at operation (October, 1922) a posterior gastro-jejunostomy had been established. After an uneventful convalescence, she had remained symptomless for about a year. In January, 1924, her gastro-intestinal symptoms had recurred while she was convalescing from a postinfluenzal mastoiditis. Two months before entering the University of California Hospital, she consulted one of us. Dietary regimen and alkalis failed to relieve her symptoms. During this period, the pain was almost constant and frequently kept her awake at night.

*Examination*—During examination the patient was found to be of a neurotic type, given to exaggeration of all her symptoms, easily upset mentally and with a tendency toward moroseness. The physical examination, except for marked diffuse tenderness over the entire epigastrium, was otherwise negative. A blood

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<sup>3</sup> Stewart, M. J., and Taylor, A. L. Adenomyoma of the Stomach, *J. Path. & Bact.* 28: 195, 1925.

pain in the foot afterward. By request, he was brought to the clinic for examination three years later. He had the slight prominence of the navicular region seen so often. The roentgenograms showed an almost normal appearance. The navicular bones had developed well and almost symmetrically. The left one was a millimeter thinner at the center and 15 mm broader from above below than the right.



Fig 10 (case 4) —The navicular bone three years after first roentgenogram. Complete restoration of function and structure after almost three years, practically without treatment.



Fig 11 (case 5) —Note swelling in the soft parts. This navicular bone has not the same density as the others. It was supposed to be "collapsed," but if it had been, the talus and cuboid would be approximated. On the contrary, the normal distance is present between them.

CASE 4—A boy, aged 5 years, three weeks before he was brought to the clinic, awoke during the night complaining of pain in his left foot, the foot was swollen. It remained swollen for two days, and then became entirely normal. Further trouble did not occur until four days ago, when the boy again awoke during the night with pain and swelling in the same foot. The pain gradually decreased. There was no history of injury. Examination showed slight swelling



verse mesocolon which allowed some distortion of the lumen of the bowel. A small scarlike area was found on the anterior surface of the pylorus. Gastrostomy revealed thickening at this point with an intact mucous membrane. The thickening was believed to represent the scar of a healed ulcer. A pylorectomy was performed, and the stomach was closed just distal to the previous gastrojejunostomy. The knuckle of jejunum which protruded through the rent in the transverse mesocolon made at the previous operation was withdrawn, and the rent was repaired by reattaching the stomach to the transverse mesocolon. The patient was returned to the ward in good condition. Recovery was uneventful.



Fig 2—Portion of tumor immediately beneath the mucosa of the stomach. Ductlike structures, undifferentiated alveoli, and alveoli of the Brunner gland and pancreatic type are seen. Reduced from a magnification of  $\times 80$ .

*Pathologic Report*—The specimen consisted of the pyloric portion of the stomach. It measured 8 by 5 by 4 cm and included about 2 cm of the duodenum. The specimen had been turned inside out. The mucosa appeared essentially normal. About 2 cm from the pyloric ring on the anterior gastric wall was a nodule 0.5 cm in diameter. This nodule was covered by intact normal-appearing mucosa. Sections through this area showed a thickening of the wall of the stomach involving chiefly the muscularis. Grossly, the appearance of the cut surface suggested an old callous ulcer.

the boy was again brought to the clinic. He then had had pain in the left foot for one day. With the exception of slight tenderness over the navicular bone, the results of the examination were negative. Roentgenograms of both feet did not show any abnormalities. The foot was strapped, and in one week was perfectly normal.

CASE 5—A boy, aged 4 years, had complained of pain in his right foot and a limp of two months' duration. He had been healthy previously, except for a little bronchial trouble, and pneumonia eight months before. The personal and family histories were not significant. About two months previously, when he arose one morning he complained of pain in his right foot, and limped. The pain grew worse for one week, and the foot swelled, but then the condition improved. For the past week it had grown worse again. The boy was in good physical condition, but he limped badly. The right foot was in slight abduction. Swelling, sensitiveness, redness and increased local temperature of the tarsus were present, with limitation of abduction and adduction and muscular spasm. The sensitiveness was most marked about the talonavicular joint. My tentative diagnosis was Kohler's disease, but the members of the department of radiology were inclined to favor the diagnosis of tuberculosis. The consultant agreed with this opinion. The foot was therefore put in plaster of paris. Four months later, other roentgenograms showed less of the shadow of the navicular bone than the first, and the roentgenographer reported "The observed progress of the disease makes tuberculosis much the most likely diagnosis." Two or three months later, the parents are said to have removed the plaster of paris and to have found the foot normal. The father expressed himself as indignant that he had been put to the expense and the trouble of treatment. Roentgenograms of this patient could not be obtained.

CASE 6—A girl, aged 5 years, was said to have jumped and sprained her right foot about one year previously. The foot had swelled at intervals ever since. It had not been painful at any time, and the child had never limped. At the time of examination, no swelling, deformity nor redness was present, nor was there any evidence of injury or disease. The roentgen rays showed a rudimentary navicular bone. The foot was strapped, and the condition soon improved. Further examination or check-up with the roentgen rays could not be obtained, but three years later, the family physician reported that the foot had been perfectly normal.

#### SUMMARY

Six cases, those of five boys and one girl, ranging in age between 4 and 6½ years, have been reported. In three, the right foot was affected, in two, the left. In one case, the symptoms were present in the left foot only, but the roentgen rays showed the appearance of the condition in both feet. In all but one case, the roentgenogram was so characteristic that the diagnosis could be made without difficulty, in that case, the diagnosis was uncertain, and the condition cleared up spontaneously. There was correspondence between the clinical picture and the roentgen-ray observations only in the fifth case. The clinical picture was that of a mild injury or infection, the roentgen-ray picture that of great "damage" to the bone. The finding of marked abnormality, by roentgen rays in an apparently normal foot shows that the "disease" may

upsets at rare intervals, always preceded by dietary indiscretions, these attacks are characterized by cramplike pain in the upper part of the abdomen and vomiting for from four to twelve hours. She is at present otherwise well.

## COMMENT

In all of the reported cases of adenomyoma of the stomach, the tumor has been located in the pyloric portion, usually within 3 cm of the pyloric ring. At operation a definite localized thickening of the

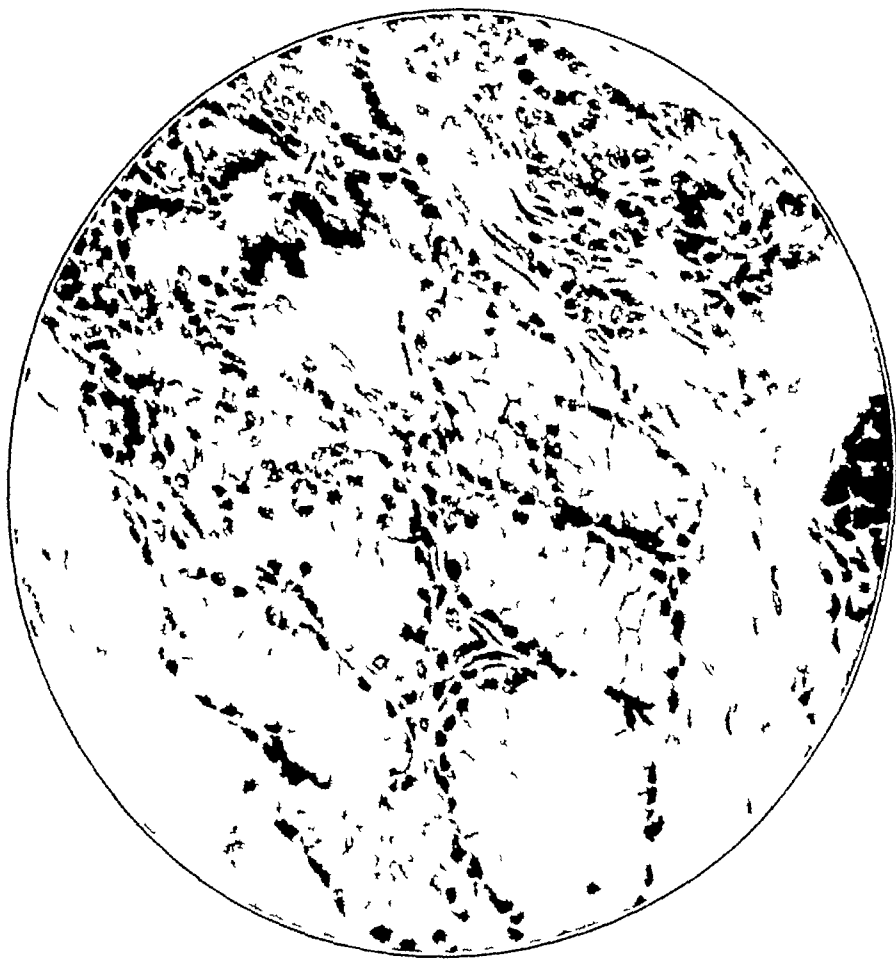


Fig 4—Brunner gland type of alveoli. Reduced from a magnification of  $\times 320$ .

wall of the stomach is always palpable. This thickening may also be visible as an ill defined and somewhat irregular bulging of the peritoneal surface of the wall of the stomach. It thus closely resembles an early carcinoma of the pylorus from its peritoneal aspect. When the stomach is opened, the mucous membrane is seen to be intact over the tumor. This intact mucous membrane at once differentiates it from a carcinoma. A cut through the tumor shows the thickening to be localized in the submucosa and muscularis. Whorls of muscle fibers may be seen

# TORSION OF THE OMENTUM WITHOUT HERNIA

## REPORT OF TWO CASES

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### CLASSIFICATION OF TORSION OF THE OMENTUM

The various types of torsion of the omentum have been classified as follows

- 1 Torsion of the omentum unassociated with hernia, adhesions or tumors
- 2 Torsion without hernia, but with old adhesions at one or more points
- 3 Torsion in a hernial sac or in the abdomen, intimately associated with the hernia
- 4 Torsion in the abdomen in conjunction with an existing or preexisting hernia, but having no connection with it
- 5 Torsion without hernia, associated with tumors of the omentum
- 6 Torsion without hernia, associated with tumors in the abdomen or pregnancy or otherwise complicated

Pure torsion of the omentum (group 1) unassociated with hernia, adhesions or tumors, is a rare condition. A search of the literature has revealed only twenty-four cases (8, 10, 14, 15, 17, 21, 22, 24, 25, 28, 29, 30, 31, 32, 33, 35, 36, 37, 39, 40, 41 and 42) to which my two cases are added.

*CASE 1—History*—A R, a man, aged 55, weighing 185 pounds (83.9 Kg), entered the Presbyterian Hospital on Aug 7, 1926, with torsion of the omentum and symptoms of acute cholecystitis. He complained of severe sharp pains and tenderness in the right upper quadrant of the abdomen of forty-eight hours' duration. He had fallen across the top of an automobile on his abdomen from the top of a stepladder forty-eight hours previously. He did not notice any pain until about four hours after the fall, when pain started over a small area in the right upper quadrant. It was cramplike and sharp, coming from every five to fifteen minutes and lasting for from three to four minutes. The pain became progressively worse, and the area of tenderness became larger. He said that it felt as though there were a mass pushing forward in this area. He worked only the remainder of the first day, and was unable to get much sleep either night. The pain was increased on breathing or on motion. It did not radiate and was no more marked when the patient was standing than when lying down. Vomiting and nausea were entirely absent. The appetite was good the first and second days, but he was unable to eat the morning of entrance because of severe pain. The bowels moved regularly.

Occasionally ducts are absent, and the alveoli form closed cystic cavities of varying sizes. The cells lining these cystic spaces are undifferentiated and embryonic. Bundles of smooth muscle fibers surround the groups of alveoli. These muscle bundles follow the tumor alveoli and ducts into the submucosa and apparently constitute an integral part of the tumor. Intermingling of the muscle bundles of the tumor and the stomach muscularis occurs. Evidences of neoplastic tendency are most

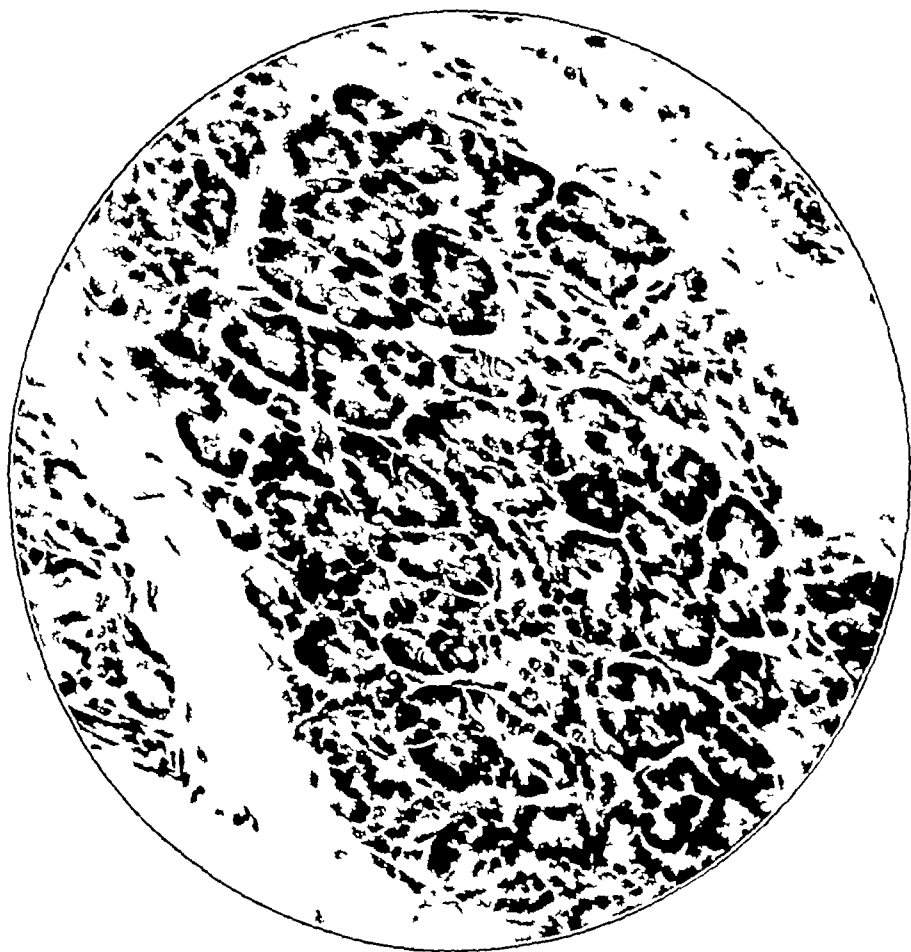


Fig 6—Nodule of pancreatic type tissue. Reduced from a magnification of  $\times 320$ .

marked in the undifferentiated alveoli which may form relatively large nodular groups. These alveoli, although active-appearing, are apparently nonfunctional. The lining cells are always in single layers and are arranged in an orderly manner. Evidences of malignancy are absent.

Malignant degeneration of these tumors is possible, but no such cases are known. As a rule, accessory organs do not show a greater tendency toward malignant change than normal organs. Accessory

CASE 2—*History*—C A, a man, aged 49, weighing 152 pounds (68.9 Kg), entered the Presbyterian Hospital on Oct 21, 1926, with torsion of the omentum and symptoms of acute appendicitis. He complained of sharp, knifelike pains in the lower right quadrant for two days. The distress in the right lower quadrant began four days previously. It followed the unusual work of putting up storm windows, in which the patient strained upward in lifting and raising the windows. The sharp pains began suddenly two days later as he was getting up from his desk. They recurred on any exertion and gradually became worse. He ate lunch,

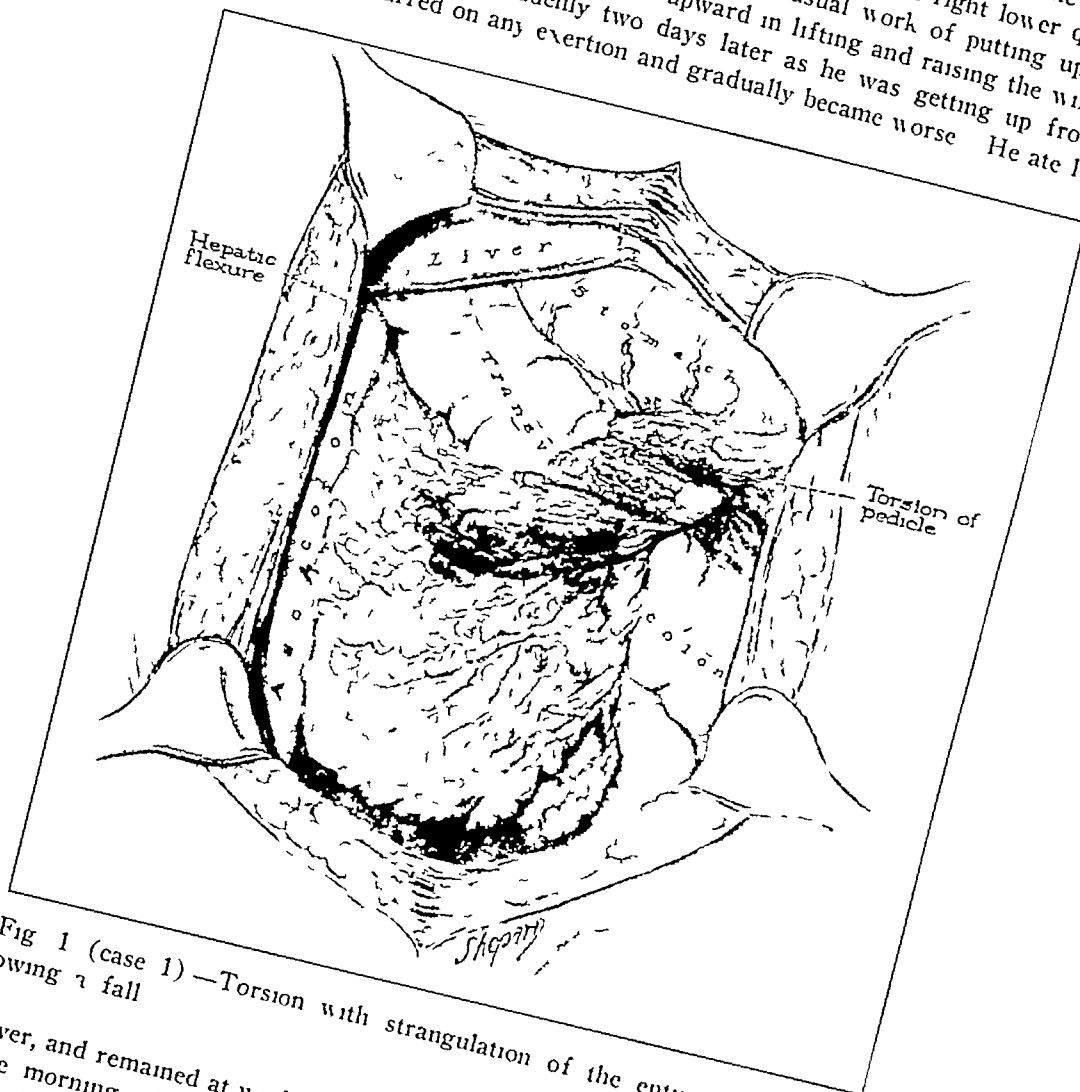


Fig 1 (case 1) —Torsion with strangulation of the entire obese omentum following a fall

however, and remained at work that day. The pains were so severe and knifelike on the morning of entrance to the hospital that he could not get up. They remained in the right lower quadrant extending somewhat around to the side but did not radiate. He felt as though his back would give way. Vomiting and nausea were absent. His appetite was good until noon on the day of entrance. The bowels moved regularly. There was no history of previous illness, operation, or abdominal disorder. He had always felt well. His weight had remained the same for several years. His occupation was largely desk work.

thoroughly studied. The case reported by Gruzdeff is remarkable because it is the only one in which the symptomatology simulated a malignancy. The severe anemia, progressive cachexia and palpable tumor all led to a clinical diagnosis of malignancy. Gastric symptoms described as "dyspepsia" were present. Complete relief followed operative removal. One of the cases reported by Stewart and Taylor gave a history of epigastric pain associated with vomiting. The pain occurred every two or three weeks in attacks lasting a week or ten days. Operation failed to relieve the symptoms, and the attacks were later diagnosed as tabetic crises. Their other two patients complained of pain coming on several hours after meals and relieved by food, vomiting did not occur. Results of a roentgen-ray examination performed in one of the cases were negative. Operation did not disclose any other pathologic gastric condition. Complete relief followed the excision of the adenomyomas. In our case the recurrence of the symptoms after operation suggested some cause other than the adenomyoma.

Judging from the reported cases, the symptomatology of adenomyoma is vague and indefinite. In rare cases, it may simulate that of an ulcer or even of a malignancy. In most cases, the symptoms are slight and probably depend chiefly on interference with the motor function of the stomach.

#### SUMMARY

- 1 Adenomyoma of the stomach represents one of the rarer heterotopias of the digestive tract.

- 2 The importance of gastric adenomyoma depends chiefly on the necessity for differential diagnosis at exploratory operations.

- 3 Definite symptomatology ordinarily is not present.

- 4 Treatment should consist of simple excision with a narrow margin of the wall of the stomach.

a dark, purplish red. It was firm and roughly oval, and most of the lobular markings were obliterated. The surface was covered with a thin layer of fibrin.

*Microscopic Examination*—Blood was infiltrated throughout the fat lobules. Some of the blood vessels were thrombosed. At the upper end of the pedicle there was considerable fibrous tissue with numerous round cells.

*Postoperative Course*—The patient made an uneventful convalescence and was discharged from hospital on the twelfth day. One year after operation, he was free from any complaint and was doing his regular work.

In group 2, torsion has been reported in three patients (34, 43 and 44) who had old adhesions so that there were two fixed points of the omentum. The rarity of torsion with adhesions alone speaks against this as a common predisposing factor.

Group 3 includes at least 75 to 80 per cent of all cases of torsion. In this group the torsion either occurred directly in the hernial sac or was intimately associated with it. In some instances, the omentum was bilocular.

In group 4, a few reported cases of torsion occurred with an existing or with a history of a preexisting hernia, but there was no evident connection. The hernia, however, may have been a predisposing factor.

In group 5, torsion occurred with tumors or cysts present in the omentum. Prutz<sup>1</sup> found that torsion occurred with sarcomas, secondary carcinomas and echinococcus cysts present.

In group 6, abdominal tumors, abnormal changes in the viscera, pregnancy or other complications were present and might have influenced the development of a torsion. Bubis<sup>2</sup> has reported torsion associated with pregnancy, Frederick<sup>3</sup> found torsion of the omentum adherent to an ovarian cyst, while in a case of Payer's<sup>4</sup> both the cyst and the omentum were twisted.

The first report of torsion of the omentum is credited by Mauclore and Ames<sup>5</sup> to Marchette in 1851, Oberst<sup>7</sup> reported another case in 1882. Both cases, however, were associated with hernia.

The first case of torsion unassociated with hernia was reported in 1899 by Eitel<sup>8</sup>. Only the twenty-six cases in group 1 are analyzed here.

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8 Eitel, G. G. A Rare Omental Tumor. M. Rec. **55** 715 (May 20) 1899.



tion, prolonged stasis, altered motility and an increase in the number of bacteria developed in the duodenum. Under these conditions, examinations were made of the blood of the twelve dogs employed in the earlier investigations. The dogs lived for periods extending from fifty-nine days to one year and forty-five days.

The studies on the blood were conducted in the following manner. At weekly intervals, a full blood count was made. This included hemoglobin determinations, red and white cell counts, differential leukocyte counts and smears for the study of the morphology of the erythrocytes. At the same intervals, the blood was examined chemically for urea nitrogen, carbon dioxide combining power and chlorides. Figures were excluded that were obtained during or after periods of vomiting, or shortly before death. In addition, the gastric contents were aspirated and examined for the presence of free hydrochloric acid in order to determine whether the reverse motility of the duodenum above the obstruction neutralized the free hydrochloric acid by reflux of the duodenal secretions into the stomach.

#### EXPERIMENTAL RESULTS

Examination of the blood showed that all of the dogs developed a moderate secondary anemia. The maximum fall in red cells varied from 1,000,000 to 2,500,000. The hemoglobin index was always below 1. Frequent remissions occurred when the red cell count was normal. In a control dog kept under the same conditions as the experimental animals for a period of 1 year and 113 days, similar, though less pronounced fluctuations in the erythrocytes were observed. Except for an occasional normoblast and slight anisocytosis, the morphology of the cells remained unchanged. There was no evidence of a blood picture resembling that of pernicious anemia.

The chemical constituents of the blood did not reveal any significant changes during symptom-free periods. Although rather marked fluctuations occurred in the urea nitrogen, comparison of the figures for dogs with duodenal obstruction with those of a series of normal dogs observed over a prolonged period by McKinley<sup>6</sup> showed that the variations in the values were not beyond normal limits. The results of the chemical analysis of the blood at the last examination of the three dogs which were observed for the longest periods are given in table 1.

Examination of the gastric contents always showed that free hydrochloric acid was present. Apparently, the reverse peristalsis which was observed fluoroscopically in the duodenum did not neutralize the gastric acidity by reflux of the duodenal contents. As achylia is characteristic of pernicious anemia, the persistence of free hydrochloric acid

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<sup>6</sup> McKinley, E. B. To be published.

angulation and pressure on portions of the colon. They found them on both sides in the majority of instances and in the absence of previous inflammatory disease. Bierman and Jones<sup>13</sup> reported a congenital accessory omentum arising from the lesser curvature of the stomach, it hung over and produced a filling defect of the stomach in one case.

In two of the cases reviewed the strangulated portion was believed to be an accessory omentum, in both of these, the pedicle was narrow. One occurred in a thin woman, while the other occurred in an obese patient. Recently, I operated on a man, aged 58 who had acute obstruction of a loop of jejunum due to omental bands. These were formed apparently by a congenital division of the end of the omentum into two portions, one of which passed through an anomalous opening in the mesentery and fused solidly with the other beneath the superior mesenteric artery. There was no obesity of the omentum. Following resection of the omentum, the uncomfortable fulness on eating that had been present all his life and the recent symptoms of obstruction immediately cleared up.

Obesity may be a predisposing factor to formation of pedicles through the tendency to a bulbous enlargement of the omentum with a narrowing at the base following unequal infiltration with fat. The production of a pedicle might easily result from pressure at the neck of the sac in a prolonged herniation of the omentum. Other factors predisposing to a pedicle in the omentum might be constriction about the waist as from a belt, constant abdominal pressure in some special work, a prolonged sitting position in obese persons and previous inflammation leaving a scar in the omentum which might also cause unequal deposits of fat.

**Hyperemia.** Hyperemia of the veins with stasis and engorgement distally may be considered the chief activating factor in producing torsion, but this action probably occurs only in the presence of a pedicle. Numerous factors might produce a hyperemia of the omentum such as cardiac weakness, traction by adhesions, pressure from within or without the abdomen, heavy or unusual work, coughing, sudden muscular contraction of the abdominal muscles, unusual positions of the body and tumor or obesity of the omentum. Hyperemia might also result from inflammation in a contiguous area such as that caused by appendicitis<sup>14</sup> or a preceding abortion<sup>15</sup>.

13 Bierman and Jones. A Third Omentum. *Surg Gynec & Obst* 36 708 (May) 1923.

14 Erdmann, J. *Ann Surg* 88 252 1921.

15 Riedel. Ueber gedrehte Netzgeschwulste mit und ohne vorgangren Bruch. *München Med Wchnschr* 52 2257 (Nov. 21) 1905 (two case reports).

the hypertrophy of the intestine found in cases of ulceration without stenosis

The renal lesions that Brown and his associates<sup>4</sup> encountered in chronic duodenal obstruction in man consisted of a "nephrosis characterized either by acute degenerative changes in the tubular epithelium or by a diffuse nephritis"

After the completion of the studies concerning the effects of experimental duodenal obstruction in dogs which were reported previously by us,<sup>5</sup> autopsies were performed and gross and microscopic examinations of the organs were made. This afforded the opportunity to investigate the histologic changes in the duodenum after prolonged stenosis. In addition, in view of the fact that in man changes in the kidneys, liver, gallbladder, joints and hematopoietic organs have been

TABLE 2—*Duration of the Obstruction, State of Nutrition and Cause of Death of Thirteen Dogs*

Dog Number	Duration of Obstruction	Nutrition	Cause of Death
8103	190 days	Good	Acute ileus
8191	1 year, 44 days	Good	Killed
8209	1 year, 45 days	Good	Killed
8295	113 days	Poor	Acute ileus
8313	73 days	Good	Acute ileus
8314	251 days	Good	Killed
8332	211 days	Poor	Acute ileus
8360	59 days	Good	Killed
8361	151 days	Poor	Acute ileus
8364	161 days	Poor	Acute ileus
8417	84 days	Poor	Acute ileus
8418	1 year, 3 days	Good	Killed
8887	51 days	Poor	Acute ileus

associated with "intestinal stasis and intoxication," a study of these organs in experimental animals was particularly interesting

#### METHOD

Immediately after death, the organs were fixed in Zenker's fluid and 10 per cent solution of formaldehyde. Paraffin sections were made and stained with hematoxylin eosin and van Gieson's stain. In addition, frozen sections were made of the liver and kidneys, and were stained with scharlach r for fat.

The twelve dogs studied previously and one additional dog not included in the earlier series constituted the material for pathologic examination. In table 2, the total duration of the obstruction, the state of nutrition and the cause of the death of the dogs is tabulated.

The obstructions existed for periods extending from fifty-one days to one year and forty-five days. Eight dogs died with symptoms of acute ileus. In six of them, the onset of symptoms was characterized by the refusal of food and rapid emaciation, with or without vomiting. In two dogs in which the nutrition remained good (8190 and 8313).

tion It followed horseback riding in Ill's<sup>22</sup> case, in Pretzsch's<sup>23</sup> case, it followed dancing, and in Cullen's<sup>24</sup> case the patient had been violently whirled around In Kohler's<sup>25</sup> patient torsion followed the hitting of a heavy object Thevenard<sup>26</sup> reported an instance following bicycle riding Wiener<sup>27</sup> believed that attacks of coughing were a cause in one case In my second case, the onset followed unusual physical exertion

Another factor in torsion, which obtains in group two is the formation of a second fixed point This may be due to the fixation of the omentum by adhesions or to incarceration in a hernial sac The mechanism of two fixed points may be compared to a folded handkerchief with two corners held taut, allowing the third corner to rotate

#### PATHOLOGY

The pedicle was at the base of the omentum with complete strangulation in eleven cases There was a narrow pedicle in two of these slightly narrowed to the size of the thumb in four, doubtful narrowing in three, no pedicle in one and twisting of the entire omentum in one Obesity was noted in the four cases in which there was only a slight narrowing at the base

The pedicle in the great omentum was not at the base and the torsion strangulated only a part of it in thirteen cases There was a pedicle the size of a pencil or smaller in nine of these a slight narrowing in two a doubtful narrowing in one and no pedicle in one which contained a twist over the entire distal half of the omentum Three of these patients were obese, including the two instances of only slight narrowing In the only patient noted as thin there was a narrow pedicle with eight twists

The pedicle was narrow in 50 per cent of the twenty-six cases, and varied in size from that of a knitting needle to that of a lead pencil There was some narrowing in 23 per cent doubtful narrowing in 15 per cent and no narrowing in 12 per cent There was an average of three complete twists of the pedicle in sixteen cases In one of Riedel's<sup>1</sup> cases there were two separate points of constriction of the omentum with torsion of each

The pedicle was usually short, but in a few instances it was several centimeters long The twist extended over the entire omentum in two

22 Ill E J Am J Obst **56** 742, 1907 (two case reports)

23 Pretzsch, E Ueber die Torsion des Netzes, Beitr z klin Chir **48** 118, 1906

24 Cullen Torsion of an Accessory Omentum Producing Symptoms Simulating Appendicitis Recovery Bull Johns Hopkins Hosp **16** 461, 1905

25 Kohler, R Netztorsion, Arch f klin Chir **3** 514, 1918

26 Thevenard Torsion aigue de l'epiploon, Paris chirurg **3** 38, 1911

27 Wiener Ann Surg **32** 648, 1900

hypertrophy of the musculature which was always present. The mucosa was normal and in some dogs had a velvety appearance. Ulcerations were found only in the two dogs which harbored masses in the lumen of the intestine; in these dogs, the mucosa was destroyed for a distance of approximately 6 cm above the obstruction.

There were usually a few thin adhesions at the site of the obstruction, which was further away from the pyloric sphincter than at the original operation owing to the lengthening of the duodenum associated with



Fig 1 (dog 8418)—Appearance of the duodenum above and below the obstruction which existed for one year and three days. The bulge above the stenosis was due to a large mass, indicated by the dotted circle, which was present in the lumen of the duodenum for at least eight months.

its hypertrophy. The muscularis was not cut through by the band in any case. The lumen of the duodenum at the stenosis was narrowed from one third to two thirds its normal diameter in the fixed specimens. At autopsy, in the fresh specimen, the degree of constriction appeared to be more marked than when the sections were examined. The muscularis was usually thinned out, the mucosa was intact and

Free fluid was noted in the peritoneal cavity in eight cases, it was bloody in five. The amount varied from a few ounces to 1 500 cc in Simon's case.

#### SYMPTOMS

There were preexisting abdominal symptoms in only two cases of this group, although in a number of cases of torsion associated with hernia, previous symptoms have frequently been noted. In Hinton's<sup>32</sup> case of torsion, there was a history of indigestion for several years and at operation for torsion, gallstones were discovered. In Skeel's<sup>17</sup> case there had been symptoms of the stomach for one year, probably due to drinking to excess. Apparently the previous symptoms were in no instance referable to the omentum, although in the majority of this group, there was a narrow pedicle which had evidently existed for some time. Previous symptoms of chronic appendicitis were completely lacking.

The duration of symptoms of torsion from the onset to the operation varied from one to seventeen days, the average duration being five days in nineteen cases, excluding Eitel's<sup>8</sup> case of over four weeks duration. The course of symptoms from the onset was usually noted as gradual and progressive over a period of several days. The first complaint usually was a discomfort in the abdomen, with development of severe and cramplike pains later. In Riedel's<sup>17</sup> case, there was vomiting eleven days before pain developed. In three other cases (Simon<sup>28</sup>, Nixon,<sup>33</sup> Cowell<sup>10</sup>), pain was not severe until after from four to ten days. The onset was noted as sudden, with acute development of symptoms in six cases.

Vomiting was noted as present in ten cases and absent in ten. It occasionally occurred before pain developed. In two cases (Scudder<sup>11</sup>, Noble<sup>34</sup>), it stopped after the onset. In two others (Simon<sup>28</sup>, Mullen,<sup>21</sup>) it occurred late, together with the increasing symptoms. In three cases (Stewart,<sup>35</sup> Skeel<sup>17</sup>, Riedel's<sup>17</sup> second case) vomiting occurred throughout the entire period. Pain and tenderness were present in all except Eitel's case. The location of pain was noted as being in the right lower quadrant in twelve cases although in one (Cowell) it began in the epigastrium. It was located in the right side in seven cases and in the right upper quadrant in two cases.

32 Hinton, J. W. Torsion of Great Omentum Producing Symptoms Simulating Acute Appendicitis, *Arch. Surg.* **13** 507 (Oct.) 1926.

33 Nixon, J. W. Torsion of the Great Omentum with Report of a Case, *Texas State J. Med.* **20** 659 (April) 1925.

34 Noble, T. B. Intra-Abdominal Torsion of the Omentum, *Ann. I. O.* **49** 364, 1904.

35 Stewart. Volvulus of the Omentum, *J. A. M. A.* **42** 767 (March) 1904.

The results in thirteen dogs showed that the average total width of the muscularis above the stenosis was 2.17 times greater than the size of the muscularis below the obstruction. A comparison of the separate components revealed that the inner circular layer contributed more than the outer longitudinal layer to the total increase. The relative average increase of the inner layer was 2.28 times, compared with an increment of only 1.85 times of the outer layer. The absolute difference in the cubical increase of the two layers was much greater. In the thirteen

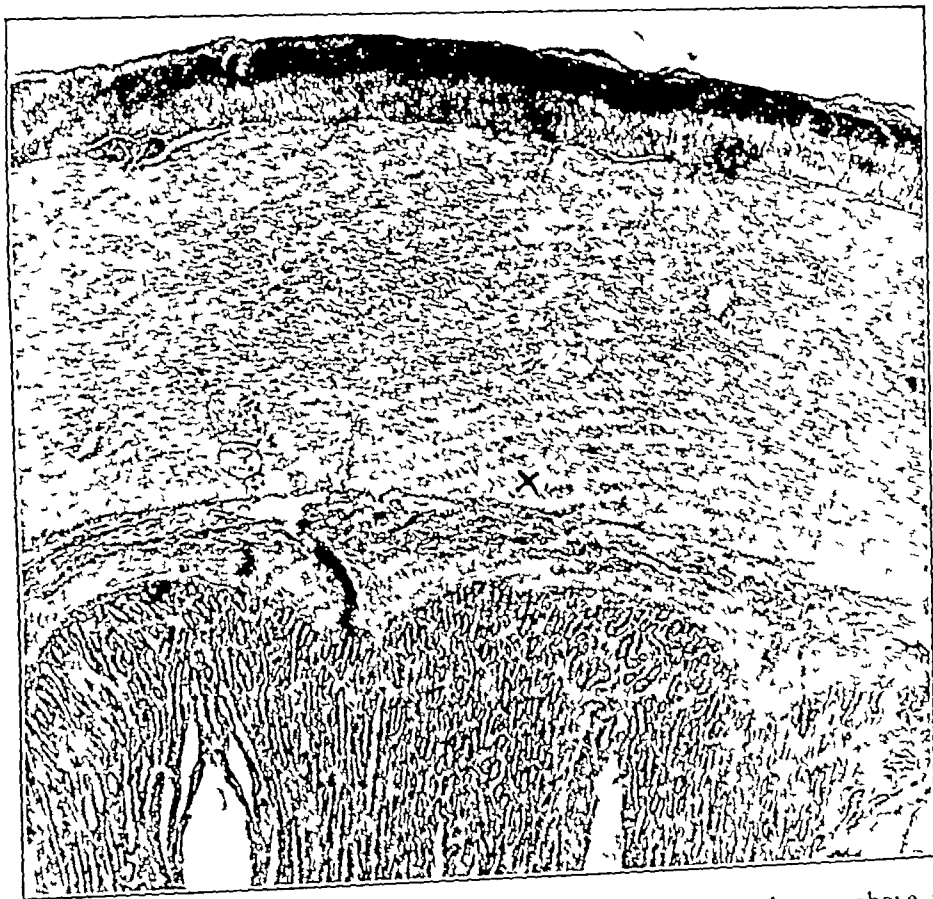


Fig 2 (dog 8332) —Hypertrophied muscularis of the duodenum above the obstruction which existed for 211 days. Note the specialized layer of muscularis described in the text, indicated by X. Compare with figure 3. Reduced from a magnification of  $\times 32$ .

dogs which were examined, the inner circular layer of the normal duodenum below the obstruction was from two and one-half to three times thicker than the outer longitudinal. Therefore, quantitatively, the bulk of the inner circular layer above the stenosis was increased many times more than that of the outer layer. These changes were more marked in some dogs than in others. The variations are indicated in the chart. The accompanying photomicrographs (figs 2 to 5) illustrate the appearance of the duodenum above and below the obstruction in

ing forty-four cases of all groups not accompanied by hernia, including tumors, Pretzsch reported six deaths, or a mortality of 14 per cent

In torsion of omentum, including cases in which hernia was present, Corner and Pinches<sup>37</sup> reported eight deaths in fifty-three cases, or a mortality of 13 per cent Pretzsch reported a fatal case of general purulent peritonitis of Moresco's, and he thought that the condition was probably embolic in origin He also reported a case of Eiselsberg's in which postoperative bleeding from the stomach followed resection of the omentum Deaths have been reported from pneumonia, infection of the gangrenous mass of omentum, obstruction of the intestine and pulmonary embolism

The appendix has been found acutely inflamed Mechanical obstruction of the transverse colon by torsion of the omentum with passage of blood and mucus was reported by Bookman<sup>38</sup> in a case in which hernia was present

Later unfavorable symptoms following removal of the entire omentum have not been noticed, according to Pretzsch

#### TREATMENT

Early operation is indicated and should usually permit the exploration of the entire abdomen There is danger of overlooking a strangulated omentum due to the edema and hyperemia of the neighboring viscera When congestion of the appendix or other viscus is not sufficient to explain the physical and laboratory observations, a further exploration of the abdomen should be made

The omentum should be resected, even if it is possible to untwist it It was resected in all but one case The appendix was removed in twelve cases and examined and left as normal in two It is possible to overlook a second torsion of the omentum higher up The blood vessels should be ligated by transfixion, as there is danger of hemorrhage and the edges should be carefully sutured When the pedicle is found at the base of the omentum, one should carefully avoid interference with the blood supply to the colon The omentum should be examined during every abdominal or hernial operation if possible especially in obese persons When there is a tendency to formation of a pedicle, it should be resected and any omental bands due to anomalies or adhesions should be cut as a prophylaxis against torsion or intestinal obstruction Following any abdominal operation, one should carefully spread out the omentum

37 Corner and Pinches *Med and Clin Tr*, London 88 611 1905

38 Bookman *Complete Torsion of the Great Omentum* *Am J Surg* 29 342 1915



mucosa. This marked increase in the amount of mucosa was a striking feature of the obstructed duodenum in all of the dogs, in some, the villi were longer and more tortuous than those below the stenosis, so that the surface area of the individual villi was also greatly increased. Pathologic changes were found in the structure of the mucosa only in the two dogs which harbored large foreign bodies in the duodenum above the obstruction. In these dogs, for a distance of approximately 6 cm above the fascial band, the greater part of the mucosa and submucosa was destroyed, forming a large ulcer of the Grawitz "decubital" type.

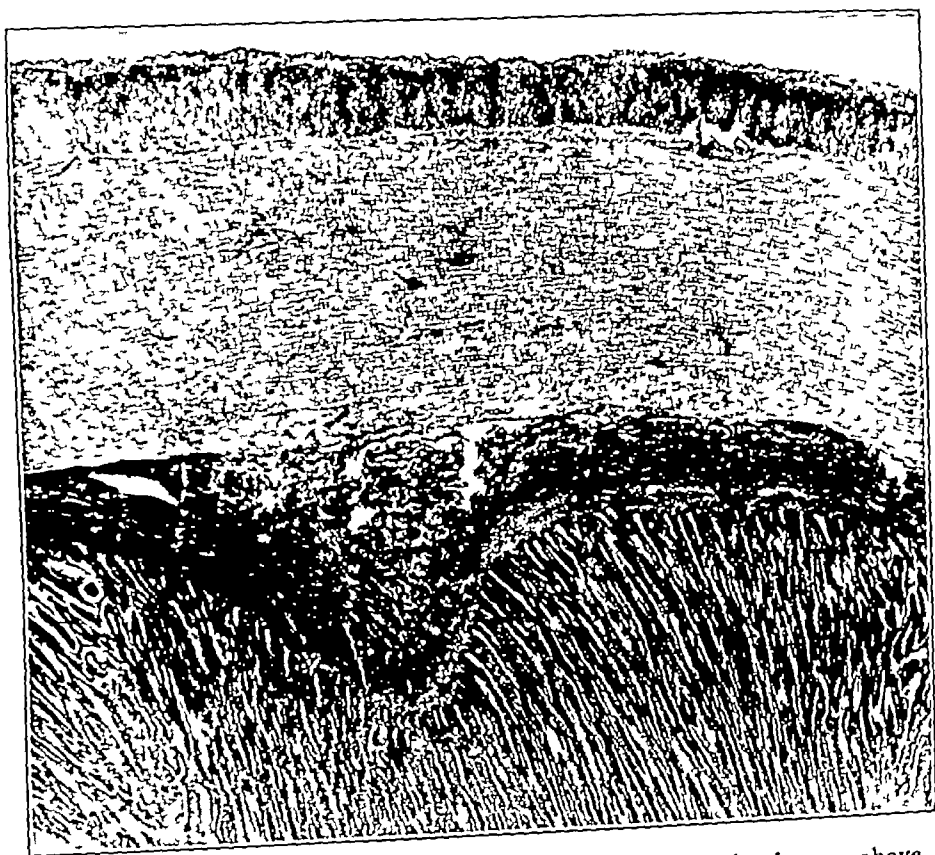


Fig 4 (dog 8887) —Hypertrophied muscularis of the duodenum above the obstruction which existed for fifty-one days. Compare with figure 5. Reduced from a magnification of  $\times 32$ .

The base of the ulcer was covered by necrotic epithelium, fibrin and granulation tissue infiltrated with polymorphonuclear leukocytes and round cells, in some places, the inflammatory reaction infiltrated the deeper muscular layers of the duodenum.

At the site of the stenosis the sling of fascia and striated muscle which was employed to produce the obstruction was united to the surface of the duodenum by a layer of connective tissue. The muscularis of the duodenum was of irregular width and showed atrophy of varying degree. The muscularis mucosae and mucosa were unchanged. The

# ADENOMYOMA OF THE STOMACH \*

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Few reports of cases of adenomyomas of the stomach are found in the literature. Many of the references to this condition are included in discussions of other closely related heterotopias of the digestive tract such as accessory islands of pancreatic tissue. Although most of these heterotopias are only of academic interest, adenomyomas have a definite clinical importance because of their closer approach to a neoplastic type of growth, the actual presence of a tumor mass, the similarity in appearance to carcinoma at operation and the possibility of clinical symptoms.

## REVIEW OF THE LITERATURE

In 1903, Magnus-Alesleben<sup>1</sup> reported a series of five adenomyomas of the stomach found accidentally at autopsy. All were quite small and situated near the pyloric ring. Microscopically, all showed alveoli of various types surrounded by smooth muscle bundles. Some of the alveoli were relatively undifferentiated, others resembled Brunner's glands, and still others were similar to pancreatic alveoli. In all the glands of the tumor connected at some point with Brunner's glands of the submucosa.

In 1909, Gruzdeff<sup>2</sup> reported the first adenomyoma of the stomach to be observed clinically. The patient, a woman aged 36 had been feeling ill for about a year. During the six weeks previous to operation she had been treated for severe anemia and dyspepsia. Gastric analysis demonstrated free hydrochloric acid. A tumor mass about the size of an apple was present in the right upper quadrant of the abdomen. It was painless, freely movable and smooth. The pre-operative diagnosis, based on the progressing cachexia and presence of the tumor, was cancer of the stomach. At operation the tumor was found embedded in the posterior wall of the stomach near the pylorus. It was removed with a narrow margin of the wall of the stomach. The patient made a complete recovery and was without symptoms six

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\* From the Department of Surgery, University of California Medical School.

1 Magnus-Alesleben, E. Adenomyome des Pylorus. *Archiv. f. klin. u. exp. Med.* **173**: 137, 1903.

2 Gruzdeff, D. A. A Rare Case of Adenomyoma of the Stomach. Heterotopia of the Epithelium of the Mucous Membrane. *Med. Obj.* **71**: 1, 1909.

was not found in either the tubules or the glomeruli. However, in a series of control animals kept under the same conditions, pathologic changes in the kidneys were far less frequent than in the experimental group of dogs.

Although conditions in the duodenum were made most favorable for the multiplication of bacteria and the elaboration of toxins, systemic effects were not produced. Whether this was due to the ability of the liver to neutralize such toxic substances, remains to be determined. The rôle of the mucosa in this defense mechanism was probably slight, for despite extensive destruction in dogs 8417 and 8418, with excellent opportunities for absorption, the end-results did not differ from those in dogs with an intact mucosa. On the other hand, the dog's liver normally harbors bacteria which have reached it through the portal circulation.<sup>11</sup> In view of the wide margin of reserve which is characteristic of the liver, even if there was increased absorption of toxins and bacteria in the presence of stasis, this natural adaptation to intestinal organisms and their products may have enabled the liver to neutralize the effects of the stenosis.

#### SUMMARY

Dogs with chronic duodenal stenosis lived for long periods practically symptom free. There was a compensatory hypertrophy of the intestinal musculature above the obstruction, the inner circular layer contributing to the hypertrophy to a greater extent than the outer longitudinal. There was also hyperplasia of the mucosa. Although prolonged stasis and an increase in the bacterial content occurred in the duodenum, significant changes were not observed in other organs.

<sup>11</sup> Berg, B. N., Zau, Z. D., and Jobling, J. W. Bactericidal Function of the Liver, *Proc Soc Exper Biol & Med* 24: 433, 1927.

count showed 95 per cent hemoglobin and 4,600,000 red blood cells. The results of urinalysis were negative. Occult blood was not present in the stool. Gastric analysis after an Ewald meal showed free hydrochloric acid to 35 in one hour and total acid to 80 in two hours. The blood Wassermann reaction was negative. Roentgenologic examination showed a small high stomach emptying through a wide gastro-enterostomy opening. There was considerable spasm of the pylorus and first portion of the duodenum. Defects were not noted. The conclusion possibly ulceration of the jejunum or at the pylorus was present.

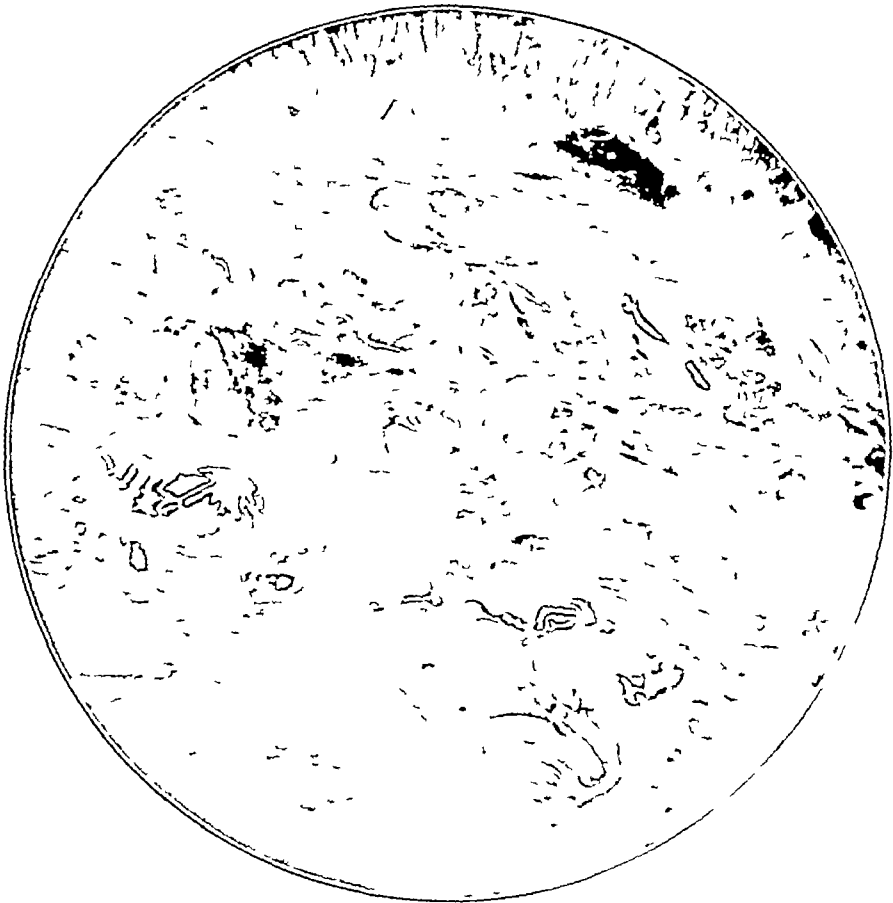


Fig 1—Entire tumor showing diffuse scattering of alveoli and ductile structures throughout the submucosa and muscularis of the stomach. Reduced from a magnification of  $\times 20$ .

*Operation*—The patient was transferred to the surgical service on March 5, 1926, for an exploratory laparotomy. The preoperative diagnosis was gastric ulcer with pylorospasm. She was operated on by one of us on the following day. Nitrous oxide and ether anesthesia was used. The incision was made over the left rectus muscle. Adhesions of the omentum to the anterior abdominal wall at the site of the former scar were present. The gallbladder was smaller than normal. The foramen of Winslow was open. The stomach was approximately normal in size, and the previous posterior gastrojejunostomy was in excellent condition except for herniation of a knuckle of jejunum through the opening.

mental intestinal obstruction would indicate that the material above the obstructing mechanism has already become sufficiently potent to extinguish the life of the animal. This time interval varies with the level of the obstruction and the variety of animal. The higher the obstruction, the more virulent is the toxin, and the smaller the animal, the sooner are the effects of the toxin manifested. For high intestinal obstructions in dogs and cats this time interval is usually from forty-eight to seventy-two hours.<sup>5</sup> Occasionally death may occur after twenty-four hours, or it may be delayed ninety-six hours or longer. For rabbits with the same type of obstruction, this interval is usually twenty hours or less. Both rabbits and dogs with obstructions in the colon live considerably longer.

Even though this theory of intoxication as the cause of death in intestinal obstruction is almost generally accepted among experimental workers,<sup>6</sup> a diversity of opinion still exists as to the actual source and nature of the toxin. Whipple and his co-workers<sup>7</sup> believed that the absorbed toxin in intestinal obstruction has its origin in the mucosa of the bowel above the obstruction rather than in the content of the bowel. They believed that the toxic element is in the nature of a heteroproteose. Nesbitt<sup>8</sup> believed that neurin and choline are the toxic bodies that produce the intoxication in obstruction. Gerard<sup>9</sup> stated that the substance is histamine. Murphy and Brooks<sup>10</sup> stated that the action of bacteria is essential for the elaboration of the toxic substance in the obstructed bowel. Dragstedt and his co-workers<sup>11</sup> were also of this

- 5 Clairmont, P., and Ranz, E. Arch. f. klin. Chir. 73 696, 1904. Dragstedt, Lester R., Moorhead, James J., and Burcky, Fred W. J. Exper. Med. 25 421 (March) 1917. Draper, J. W. Intestinal Obstructions, J. A. M. A. 67 1080 (Oct. 7) 1916. Murphy, F. T., and Brooks, Barney. Intestinal Obstructions Arch. Int. Med. 15 392 (March) 1915. Sugito, S. Mitt. d. med. Fak. d. Univ. Kyushu Fukuoka 9, 229, 1924.
- 6 Gerard, R. W. Chemical Studies on Intestinal Intoxication, The Presence and Significance of Histamine in an Obstructed Bowel, J. Biol. Chem. 52 111 (May) 1922.
- 7 Whipple, G. B., Stone, H. B., and Bernheim, B. V. J. Exper. Med. 17 287, and 307, 1913, ibid. 19 144 and 166, 1914. Whipple, G. H. Rodenbaugh, F. H., and Kligore, A. R. ibid. 23 123 (Jan) 1916. Whipple, G. H., Cooke, J. V., and Stearns, T. J. ibid. 25 461 (March) 1917.
- 8 Nesbitt, Beattie. On the Presence of Cholin and Neurin in the Intestinal Canal During Its Complete Obstruction, A Research on Auto-Intoxication J. Exper. Med. 4 1, 1899.
- 9 Gerard, R. W. (footnote 6). The Lethal Agent in Acute Intestinal Obstruction, J. A. M. A. 79 1581 (Nov.) 1922.
- 10 Murphy, F. T., and Brooks, Barney. (footnote 5, journal reference).
- 11 Cannon, Paul R., Dragstedt, Lester R., and Dragstedt, Carl A. Intestinal Obstruction, A Study of the Influence of the Bacterial Flora on the Toxemia of Acute Obstruction, J. Infect. Dis. 27, 139 (Aug.) 1920. Dragstedt, Lester R., Moorhead, James J., and Burcky, Fred W. (footnote 5, second reference).

Microscopic examination of sections through the nodule showed an intact essentially normal, mucosa. The submucosa was thickened and fibrous. Numerous glands and ductlike structures were present in scattered groups throughout the submucosa and muscularis. Some of these glands resembled pancreatic acini while others approached the type of the Brunner gland. Undifferentiated alveoli and intermediate types were numerous and made up the bulk of the tumor. These glandular structures appeared essentially normal in all respects except location. There was no suggestion of malignancy. Narrow strands of smooth muscle apparently distinct from the muscularis of the stomach surrounded these alveoli



Fig 3—Ductlike structure surrounded by distinct bundles of smooth muscle. Reduced from a magnification of  $\times 80$ .

The muscularis of the stomach showed some diffuse fibrosis and was moderately infiltrated with lymphocytes and plasma cells. The dissection of the stomach

*Subsequent Course*—The patient kept ill for 22 months, 1926, against our advice, immediately returned home. In 1927, attacks of vomiting finally compelled her to seek medical attention. She showed gastric emptying by the gastric tube, and was slightly more rapid than normal. Four weeks later she had regained 12 pounds (5.4 kg) in weight and a better appetite. It also gave her a happy outlook on life. She

dogs were injected with intestinal contents prepared in the manner. On the number, seven were injected with the contents of a dead dog. In five instances, the intestinal contents were used that were collected from above the point of obstruction in four dogs. Material was obtained from one of the point of obstruction for four injections from two of these four dogs. In one instance, the intestinal contents were collected from an obstructed loop drained by a catheter both ends of the loop being set turned in. A synopsis of the reactions noted are listed in Table I.

Table I—*Intravenous Injection of the Intestinal Contents of a Dog*

Dog	Source of Material	Amount Injected	Reaction	Remarks
1	Upper loop of dog with intestinal obstruction	12	Death, vomited, diarrhea, salivation, irregular pulse occurred after 20 minutes. Lethargy after 30 minutes. Three days later recovered after having exhibited actual rigor.	Recovery after 30 minutes.
2	Upper loop of dog with intestinal obstruction	10	Recovery after 30 minutes. Vomited, diarrhea, salivation, irregular pulse occurred after 20 minutes. Lethargy after 30 minutes. Three days later recovered after having exhibited actual rigor.	Recovery after 30 minutes.
3	Upper loop of dog with intestinal obstruction	7	Recovery after 30 minutes. Vomited, diarrhea, salivation, irregular pulse occurred after 20 minutes. Lethargy after 30 minutes. Three days later recovered after having exhibited actual rigor.	Recovery after 30 minutes.
4	Lower loop of dog with intestinal obstruction	7	Death, vomited, diarrhea, salivation, irregular pulse occurred after 20 minutes. Lethargy after 30 minutes. Three days later recovered after having exhibited actual rigor.	Recovery after 30 minutes.
5	Normal	10	Death, vomited, diarrhea, salivation, irregular pulse occurred after 20 minutes. Lethargy after 30 minutes. Three days later recovered after having exhibited actual rigor.	Recovery after 30 minutes.
6	Upper loop of dog with intestinal obstruction	12	Death, vomited, diarrhea, salivation, irregular pulse occurred after 20 minutes. Lethargy after 30 minutes. Three days later recovered after having exhibited actual rigor.	Recovery after 30 minutes.
7	Normal	9	Death, vomited, diarrhea, salivation, irregular pulse occurred after 20 minutes. Lethargy after 30 minutes. Three days later recovered after having exhibited actual rigor.	Recovery after 30 minutes.
8	Lower loop of dog with intestinal obstruction	10	Death, vomited, diarrhea, salivation, irregular pulse occurred after 20 minutes. Lethargy after 30 minutes. Three days later recovered after having exhibited actual rigor.	Recovery after 30 minutes.
9	Normal	10	Death, vomited, diarrhea, salivation, irregular pulse occurred after 20 minutes. Lethargy after 30 minutes. Three days later recovered after having exhibited actual rigor.	Recovery after 30 minutes.
10	Normal	10	Death, vomited, diarrhea, salivation, irregular pulse occurred after 20 minutes. Lethargy after 30 minutes. Three days later recovered after having exhibited actual rigor.	Recovery after 30 minutes.
11	Lower loop of dog with intestinal obstruction	10	Death, vomited, diarrhea, salivation, irregular pulse occurred after 20 minutes. Lethargy after 30 minutes. Three days later recovered after having exhibited actual rigor.	Recovery after 30 minutes.
12	Lower loop of dog with intestinal obstruction	10	Death, vomited, diarrhea, salivation, irregular pulse occurred after 20 minutes. Lethargy after 30 minutes. Three days later recovered after having exhibited actual rigor.	Recovery after 30 minutes.
13	Normal	10	Death, vomited, diarrhea, salivation, irregular pulse occurred after 20 minutes. Lethargy after 30 minutes. Three days later recovered after having exhibited actual rigor.	Recovery after 30 minutes.
14	Normal	10	Death, vomited, diarrhea, salivation, irregular pulse occurred after 20 minutes. Lethargy after 30 minutes. Three days later recovered after having exhibited actual rigor.	Recovery after 30 minutes.
15	Normal	10	Death, vomited, diarrhea, salivation, irregular pulse occurred after 20 minutes. Lethargy after 30 minutes. Three days later recovered after having exhibited actual rigor.	Recovery after 30 minutes.
16	Upper loop of dog with intestinal obstruction	10	Death, vomited, diarrhea, salivation, irregular pulse occurred after 20 minutes. Lethargy after 30 minutes. Three days later recovered after having exhibited actual rigor.	Recovery after 30 minutes.
17	Upper loop of dog with intestinal obstruction	10	Death, vomited, diarrhea, salivation, irregular pulse occurred after 20 minutes. Lethargy after 30 minutes. Three days later recovered after having exhibited actual rigor.	Recovery after 30 minutes.

\* Two days later  
 † Three days after second injection  
 ‡ Drained off through catheter  
 § Obtained through gastroscope tube

COMMENT

There were two deaths following the injection of intestinal contents prepared as described, into seventeen normal dogs. Both deaths occurred following the intravenous injection of normal intestinal contents. The reactions of the dogs, however, were mild. A few reactions were mild. Vomiting, diarrhea, salivation and irregular pulse occurred after 20 minutes. In a few instances, dogs recovered after having exhibited actual rigor and coma.

entering the tumor mass. Pin-point cystic cavities are frequently visible, occasionally small plugs of secretion and epithelial debris may be expressed by pressure. When these cystic cavities are absent the tumor may closely resemble the scar of an old callous ulcer. Microscopically, glandular structures are found throughout either the submucosa and the muscularis or throughout both. These glandular structures are frequently grouped into nodules of varying sizes. Many alveoli appear relatively undifferentiated. These are lined by dark

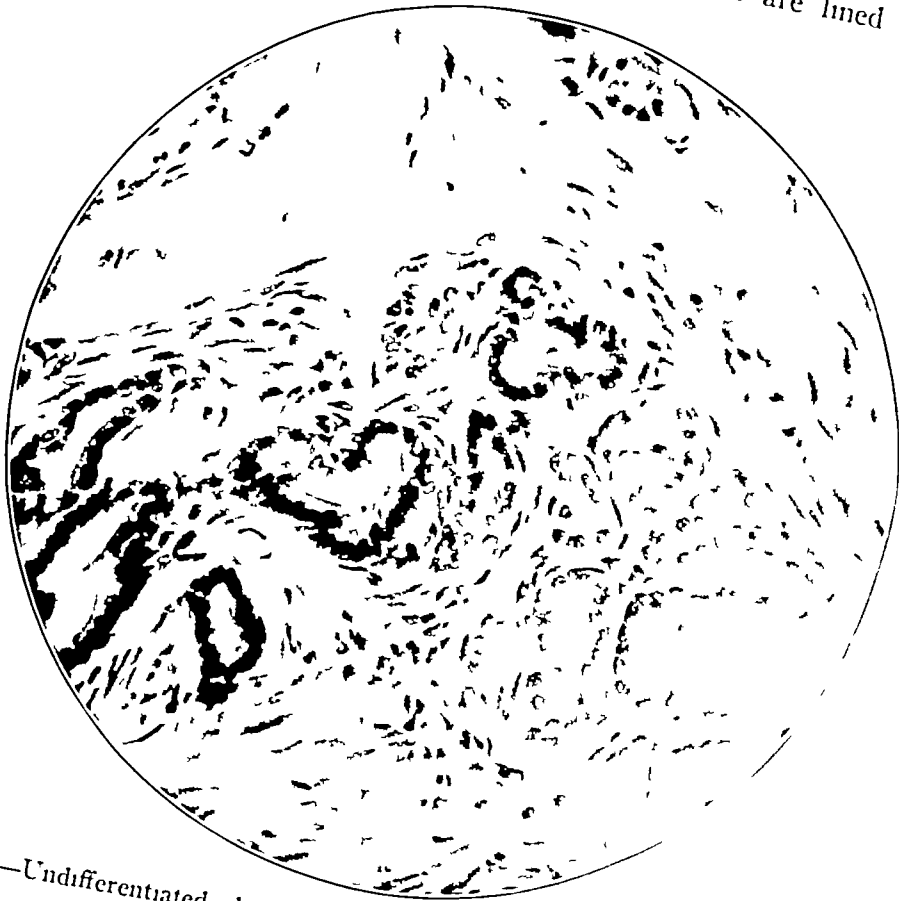


Fig 5—Undifferentiated alveoli. Reduced from a magnification of 250. staining cells with round to oval nuclei which ranged from cuboidal to columnar in shape. The cells, although undifferentiated and embryonic in character, appear active. They resemble the lining cells of the biliary and pancreatic ducts rather than gastric or intestinal mucosa. Differentiated alveoli resembling either pancreatic islet or Brunner's glands are also present. Usually all three types are found. One may dominate the picture. The alveoli open into duct-like structures which eventually communicate with the lumen of the stomach.



These reactions noted in so large an animal as the dog are largely qualitative and subject to the criticism that the intravenous injection of any fluid containing protein substances would be expected to elicit reactions. In order to get away from this objection and to obtain better quantitative results, small rats were injected intraperitoneally with intestinal contents prepared in the same manner as that obtained from both dogs and rabbits. The intestinal contents of the dog were used thirty-six times in sixty-six such injections into the peritoneal cavity of the rat, and in thirty instances, the intestinal contents of the rabbit were used. The source of the intestinal content of the dog was the same as that employed in the intravenous injection of the dogs already enumerated. The contents of the rabbit were obtained from the intestine of two normal rabbits and from two rabbits with intestinal obstruction in which the lower ileum had been tied off by gauze two days previously.

TABLE 2—*Rats Injected Intraperitoneally with the Intestinal Contents of the Dog*

	Number of Rats Injected	Average Amount Injected, Cc.	Sick	Ataxic	Clonic Spasms	Coma tose	Died	Recovery
Normal	13	5.8	13	3	1	3	1	12
Fluid from above severed gut obstruction	11	5	11	4	1	2	1	10
Fluid from below severed gut obstruction	12	4.8	12	7	3	7	0	3

The rats employed for injection weighed on the average about 75 Gm, a number weighed as little as 30 and 33 Gm, and a few as much as 200 Gm.

Thirteen rats were injected with the intestinal contents of the normal dog. In eleven instances, the material was obtained from above the point of obstruction in dogs with intestinal obstruction, and in twelve instances the fluid injected was from the loop of bowel below the severed gut obstruction. Thirteen of the thirty-six rats injected died. Nine died following the injection of intestinal contents obtained from the bowel below the point of obstruction. One died following the injection of normal intestinal contents, and another after the injection of contents obtained from above the point of obstruction in a severed gut obstruction.

All the animals injected were ill. Apathy and stupor were the usual symptoms. Ataxia was frequently observed. Clonic spasms were observed in a few instances. Coma was observed when death occurred shortly following the injection. A comatose condition was also observed in a few that recovered. In three instances, death occurred within six minutes from the time of injection, in one instance, three minutes after

pancreases are relatively common yet Nicholson<sup>4</sup> could find only three cases of carcinoma arising in an accessory pancreas. Adenomyomas show more tendency toward a neoplastic type of growth than accessory pancreatic nodules, but their rarity reduces to a negligible factor the possibility of their being the origin of a carcinoma. It must also be remembered that such an origin would be extremely difficult to prove. It would be necessary to discover the carcinoma before involvement of the gastric mucosa had occurred, and a carcinoma of such size would be discovered only accidentally at exploratory operation or at autopsy following death from other causes.

Adenomyoma of the stomach represents one of the many heterotopias of the digestive tract. It is of congenital origin and develops from epithelial buds or diverticuli. Accessory pancreases arising from similar epithelial buds form the commonest heterotopia of this type. Unlike the pancreatic heterotopias adenomyoma tends to remain wholly or in part undifferentiated, or to differentiate in two directions, that is, toward both the Brunner gland and the pancreatic types. As a result, most adenomyomas show three types of glands—undifferentiated Brunner gland type and pancreatic type. The undifferentiated alveoli usually predominate and approach a neoplastic type of growth. Strands of smooth muscle are associated with the tumor. In some cases the connection of the epithelial bud with the lumen of the stomach becomes lost, and either single or multiple cystic cavities result. The latter heterotopias, we believe, can be considered adenomyomas only if the cystic spaces are lined by epithelial cells similar to those of the undifferentiated type of alveoli and show the same proliferative tendency. The adenomyoma reported by Gruzdeff is an example of this type.

Lauche reserves the term adenomyoma for those heterotopias in which differentiation does not lead to the formation of pancreas-like acini. He classifies heterotopias similar to the condition in our case and in the cases reported by Magnus-Alsleben, Stewart and Taylor as incompletely differentiated accessory pancreases. Although intermediate forms between true accessory pancreases and adenomyomas occur, we believe with Stewart and Taylor that the presence of undifferentiated alveoli with neoplastic tendencies justifies the inclusion of these growths in a separate group as adenomyomas.

The clinical significance of these adenomyomas depends partly on the necessity for differential recognition at operation and partly on the possibility of clinical symptoms. The exact symptomatology is open to doubt. Most of the reported cases were discovered accidentally at autopsy. Those observed clinically have not on the whole been

<sup>4</sup> Nicholson, G. W. Studies in Tumor Formation. *Gov's Hosp. Rep.* 73: 37, 1923.

precedent Kukula<sup>17</sup> concluded from his experiments on dogs that both normal and obstructed intestinal contents are toxic Magnus-Alsleben<sup>18</sup> similarly found that the intestinal contents of both the normal dog and the dog with intestinal obstruction was toxic He observed that the feeding of meat increased the toxicity of normal intestinal contents, the feeding of milk and cheese did not enhance the toxicity Roger and Garnier<sup>19</sup> stated that normal intestinal contents are even more toxic than the contents from the animal with intestinal obstruction They observed that the duodenal contents are more toxic than the contents of the lower ileum or colon<sup>20</sup> Braun and Borrutau<sup>21</sup> also made the observation that in the experimental animal, normal intestinal contents are just as toxic as those from animals with intestinal obstruction

In this study, we have not attempted to establish comparisons between the toxicity of intestinal contents at different levels of the intestine in the normal animal, nor have we endeavored to ascertain the nature of the toxin in the intestinal contents of the normal animal or the animal with intestinal obstruction The only deductions that we feel can be made from this study are that the normal intestinal contents of both the dog and the rabbit are toxic on injection when submitted to the same treatment as the contents from obstructed animals It would also appear that the normal intestinal contents are as toxic as the contents from the obstructed intestine, and that in the dog with intestinal obstruction, the material below the point of obstruction is even more toxic on injection than the fluid obtained from above the obstructing mechanism

We are aware of the fact that in experiments of this nature there are factors that are not controlled The dilution of the fluid found in the obstructed and nonobstructed segments is probably the most important Several investigators have failed to find intestinal contents that have passed through the Berkefeld filter to be toxic In some rats injected with intestinal fluid obtained from starved animals (both normal dogs and dogs with intestinal obstruction) and prepared as outlined, the symptoms were mild We also injected twelve rats with the intestinal contents of two dogs in which duodenal obstructions were established

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17 Kukula Untersuchungen über autointoxication bei Darmocclusionen, Arch f klin Chir **63** 773, 1901

18 Magnus-Elsleben, Ernst Ueber die giftigkeit des normalen Darminhalts, Beitr z chem Phys u Path **6** 503, 1906

19 Roger, H, and Garnier, M Compt rend Soc de biol **59** 388, 673 and 677, 1905

20 Roger, G H Presse med **32** 901 (Nov) 1924 Roger, H, and Josue O ibid **60** 371, 1906 Roger, H, and Garnier, M ibid **60** 666, 1906

21 Braun, W, and Borrutau, H Experimental kritische untersuchungen ueber den Ileus Tod, Deutsche Ztschr f chir **96** 544, 1908

# EXPERIMENTAL CHRONIC DUODENAL OBSTRUCTION, CHANGES IN THE BLOOD AND OTHER PATHOLOGIC CHANGES.\*

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Our primary object in the experimental production of chronic stenosis of the duodenum was to determine whether there was any relationship between intestinal stasis and alterations in the blood. Clinically, Lowenberg<sup>1</sup> and Olivet<sup>2</sup> found an increase in the bacterial content of the duodenum in cases of pernicious anemia. Experimentally, Seyderhelm<sup>3</sup> claimed to have produced a pernicious anemia-like picture in dogs with chronic obstructions of the small intestine. Brown and his co-workers<sup>4</sup> reported the occurrence of 'toxic nephritis' in a series of cases of chronic duodenal obstruction. Functional studies of the kidneys indicated renal insufficiency. Chemical examination of the blood revealed an increase in the urea nitrogen and creatinine, a high carbon dioxide carrying capacity and a low chloride content.

In previous papers,<sup>5</sup> a new technic for producing chronic stenosis of the duodenum was described. The duodenum was chosen as the site of the obstruction because normally, this segment of the intestine is relatively free from bacteria and the rate of motility is more rapid than in any other part of the intestinal tract. As a result of the obstruc-

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## CONSTRUCTIONS

- 1 All intestinal contents are toxic on injection
- 2 The intestinal contents of the normal dog and rabbit elicit the same symptoms on injection as do the contents of the obstructed bowel, and are just as toxic
- 3 In the dog with intestinal obstruction, the intestinal contents from below the point of obstruction appear even more toxic on injection than the fluid obtained from above the obstructing mechanism

in the stomach in the experimental animals may have been of some importance in the results

#### PATHOLOGY

The anatomic changes which occur above a chronic obstruction in the intestine in man have been described by numerous observers<sup>7</sup> however, due to the inability of previous investigators to produce experimental chronic intestinal stenosis, little has appeared in the literature concerning this phase of the subject. Herczel,<sup>8</sup> one of Nothnagel's pupils, studied the effects of incomplete stenosis of the intestine in rabbits. Although none of his animals survived longer than sixteen days, he attempted to interpret the nature of the compensatory muscular hypertrophy which developed in chronic intestinal obstruction. He found that an increase in the thickness of the intestinal wall began as early as the fourth or fifth day after the obstruction was established and that hypertrophy was pronounced on the ninth day. Lengthening of

TABLE 1—Results of Last Chemical Examination of the Blood of  
Three Dogs Observed for the Longest Periods

Dog Number	Degree of Dilatation*	Duration of Obstruction at Time of Last Blood Examination	Urea Nitrogen Mg. per 100 Cc.	Chlorides Mg. per 100 Cc.	Per Cent of Carbon Dioxide by Volume
8191	++++	1 year 29 days	22.5	4	48
8209	+++	1 year 23 days	27.0	4.4	48
8418	++++	11 months	17.1	4.8	4

\* +++ indicates dilatation approximately twice the diameter of the normal lumen.  
++++ indicates dilatation more than twice the diameter of the normal lumen.

the intestine above the stenosis was associated with the hypertrophy. The other structures of the wall of the bowel did not partake of this change. Herczel concluded that the increased thickness of the intestinal wall above the obstruction was due to a true muscular hypertrophy in the sense of Anichow.

In chronic intestinal obstruction in man, ulceration of the mucosa has been noted frequently in the segment immediately above the obstruction. Patel<sup>9</sup> believed that intestinal hypertrophy occurred only when a lesion of the mucosa was associated with the stenosis, the degree of the hypertrophy depending on the number of excitatory impulses sent from the irritated mucous membrane. In this way he accounted for

7 Nothnagel H. Diseases of the Intestine and Peritoneum. Philadelphia: W. B. Saunders Company, 1907. p. 355.

8 Herczel F. Experimentelle und histologische Untersuchungen über die kompensatorische Musch hypertrophie bei Darmstenosen. *Zentralblatt für Chirurgie* 11: 321, 1886.

9 Patel M. Remarques sur l'etat de l'intestin au-dessus d'une stenose. *Ann. med.* 93: 73, 1901.

patients have been followed varies from five to sixty years, the average being 24.5 years. At the time of operation, 18 of the patients were between 14 and 20 years of age, 24 between 20 and 30, and the ages of the rest ranged from 30 to 60. Ollier aimed to restore function, and the results are classified on the functional basis. Complete ankylosis, even though the arm is in good position and useful, is rated as a bad result. The results were found to be as follows: Very good, 26 cases (when the mobility and power exceed two thirds of the normal), good, 15 cases (when one of the two factors mentioned is less than two thirds of the normal but greater than one third of the normal), fairly good, 8 cases (when one of the two factors falls below one third of the normal), bad, 6 cases (more or less complete ankylosis or a flail joint). On the whole, the results were satisfactory in 52 out of 55 cases, or 95 per cent. Perfect results were found in 48 per cent, meaning that the resected side is practically as good as the healthy side, in both power and mobility. Comte pointed out that there is not an absolute relation between the excellence of the anatomic result and of the functional result. In 13 cases, active pulmonary or local tuberculous lesions were present. Two of the patients died six and seven years later.

2 Resections for Ankylosis. Ollier found the results of resection so good in tuberculosis that he applied it as a method for securing mobilization of ankylosed joints. To prevent recurrence of ankylosis, he advised resection of from 5 to 6 cm. of bone and excision of the capsule and periosteal structures about the joint. In 12 resections for arthritis, the results were excellent in 8, good in 2, poor in 1, and bad in 1 (ankylosis recurred, and a second operation was performed later with good results). In 9 resections for fracture or irreducible dislocation, the results were perfect in 3 and bad in 1 (good results were obtained after the second operation). In 5 semiarticular (humeral) resections, the results were excellent in 4 and good in 1. When grouped together, the results were perfect in 76.5 per cent of the cases, good in 19 per cent and poor in 4 per cent. The author compared these figures with the results reported by American surgeons in 126 patients with arthroplasty of the elbow. Good results were obtained in 76 per cent, poor results in 16 per cent, and bad in 6 per cent. Comte concluded that, when compared with arthroplasty of the elbow, the operation of resection appears to be the more successful.

[ED COMMENT—Comte has made a thorough and painstaking investigation, and the report is deserving of careful study. If a patient with tuberculosis of the elbow can be cured and mobility preserved by resection, this is a better operation than arthrodesis. The operation of

the onset of anorexia was more abrupt with sudden severe vomiting and prostration. The five remaining dogs were killed during exploratory operations. Their nutrition was good. The three female dogs (8399, 8399 and 8418) became pregnant and had litters during the experiment.

In most of the dogs the lumen of the duodenum completely occluded at the site of the obstruction at autopsy. The degree of the dilatation of the stomach in relation to the development of symptoms was variable. In the dog which lived for the longest periods after the onset of acute anorexia the stenosis was more pronounced than in the other dogs that died earlier or later. In this connection it was of interest to note the variation in the susceptibility of different dogs to the artificial stenosis. After what was considered to be a moderate stenosis a severe one had been produced in some dogs dead at autopsy a few days after the operation with few objective symptoms. The dogs which died stated that the stenosis was light or moderate but the dilatation above the fixed band was not dilated and that the stomach was normal. On the other hand other dogs withstood more complete degrees of obstruction without difficulty.

In two dogs (8417 and 8418) the lumen of the duodenum immediately above the stenosis was filled by a hard mass which measured 4 to 5 cm. and which consisted of hair and debris matted together. By exploratory operations and fluoroscopic examinations it was determined that the mass had been present for at least six weeks in the duodenum of dog 8417 before the onset of symptoms of obstruction. In dog 8418 it had been present for at least eight months before the onset of anorexia. At fluoroscopy it was noted that the barium flowed around the masses in a thin stream showing that the obstruction was incomplete.

The usual gross appearance at autopsy of the upper abdominal viscera after chronic duodenal stenosis is shown in the accompanying drawing of dog 8418 which had an obstruction for one year and three days (fig. 1). In ten dogs the stomach was unaltered, in three dogs which developed acute ileus the stomach was markedly distended. The musculature was not thickened. The liver, gallbladder and pancreas appeared normal. In some of the animals, the common duct was dilated.

The most significant pathologic changes were found in the duodenum above the stenosis. Dilatation was present in varying degrees, the observations corresponded roughly with the observations which were made at fluoroscopy and exploratory operation.<sup>4</sup> The amount of dilatation in the different dogs varied roughly between one and three times the diameter of the duodenum below the obstruction. The segment of the duodenum above the stenosis was lengthened, owing to the



function, then the best result is obtained by putting it to use, as in the author's operation. When this is not the case, the head should be removed and the neck placed in the acetabulum.

Mathieu and Wilmoth<sup>43</sup> discussed the various operative methods for obtaining ankylosis of the hip in tuberculosis and classified them as intra-articular freshening of the articular surfaces, the extra-articular arthrodesis by rigid bone grafts and the para-articular method of transplanting the greater trochanter. They favored either the latter method which is essentially the Hibbs operation, or a method with osteoperiosteal grafts, in which a flap of bone is turned down on the capsule from the ilium, and the space between this and the bared trochanter filled in with osteoperiosteal shavings from the opposite tibia.

*An Operation for Stabilizing Paralytic Hips*—In a preliminary report, Dickson<sup>44</sup> described an operation for stabilizing paralytic hips which he used for five years. The procedure is designed to replace the paralyzed glutei muscles by the tensor fasciae femoris. He transplanted the origin of the tensor fasciae femoris with a piece of its bony attachment to a groove in the crest of the ilium near the posterior superior spine. The muscle is passed through a tunnel beneath the gluteus medius. The indications for the operation, according to Dickson, are (1) flexion contracture of the hip, (2) relaxed subluxating hip, (3) holding of a luxated hip in the acetabulum after reduction. The author reported having performed the operation in forty cases, details of which are to be presented in a later paper.

*Operation for the Relief of Paralysis of the Gluteus Maximus Muscle*—Ober<sup>45</sup> devised an interesting and apparently successful operation for paralysis of the gluteus maximus muscle. An incision is made from the level of the first lumbar vertebra, 1 inch (2.5 cm) lateral to the spinous processes, downward opposite the posterior inferior spine of the sacrum, exposing the gliding fascia over the muscles in this region. The fascia is incised longitudinally near the spinous processes and is cleared from the muscle. The outer half of the erector spinae, with its aponeurosis, is separated from the inner half and from the muscles lateral to it, the incisions being carried down to the lower end of the incision in the skin. The muscle thus split off is freed from the body and crest of the ilium, from the sacrum, and from the transverse processes in such a way that a free flap of muscle, about 5 inches (12.7 cm) long, 1 inch wide, and  $\frac{3}{4}$  inch (1.8 cm) thick is obtained.

43 Mathieu, P., and Wilmoth. *J de chir* 28 130 (Aug) 1926

44 Dickson, Frank D. *J Bone & Joint Surg* 9 1 (Jan) 1927

45 Ober, Frank R. *Operation for Relief of Paralysis of Gluteus Maximus Muscle*, *J A M A* 88 1063 (April 2) 1927

ulcerations were not present. Below the obstruction, the duodenum and the small intestine were normal.

There was no correlation between the degree of the obstruction and the amount of dilatation and hypertrophy of the duodenum. In some cases the changes were more marked than in others, although grossly decreased or absent obstruction was the same or even less. This correlation due to the variation in dilatation and dilatation of the duodenum which were observed histologically in duodenitis, approximately the same extent of stenosis. Individual difference in the tonus of the muscularis is also a factor in the dilatation of the smooth muscle to compensate for the resistance to the hypertrophy and in avoidable differences in the degree of the stenosis. These were probably the factors underlying the variations in the degree of stenosis in the duodenum.

TABLE I. The degree of stenosis and dilatation of the duodenum and below Stenosis

Case	Above Stenosis		Below Stenosis		Total Width of Muscularis	
	Length (mm)	Width (mm)	Length (mm)	Width (mm)	Below Stenosis (mm)	Above Stenosis (mm)
1	1	1	1	0.1	0.1	1.1
2	1	1	1	0.1	0.7	1.1
3	1	1	1	0.1	0.1	1.1
4	1	1	1	0.1	0.1	1.1
5	1	1	1	0.1	0.1	1.1
6	1	1	1	0.1	0.1	1.1
7	1	1	1	0.1	0.1	1.1
8	1	1	1	0.1	0.1	1.1
9	1	1	1	0.1	0.1	1.1
10	1	1	1	0.1	0.1	1.1
11	1	1	1	0.1	0.1	1.1
12	1	1	1	0.1	0.1	1.1
13	1	1	1	0.1	0.1	1.1
14	1	1	1	0.1	0.1	1.1
15	1	1	1	0.1	0.1	1.1
16	1	1	1	0.1	0.1	1.1
17	1	1	1	0.1	0.1	1.1
18	1	1	1	0.1	0.1	1.1
19	1	1	1	0.1	0.1	1.1
20	1	1	1	0.1	0.1	1.1
21	1	1	1	0.1	0.1	1.1
22	1	1	1	0.1	0.1	1.1
23	1	1	1	0.1	0.1	1.1
24	1	1	1	0.1	0.1	1.1
25	1	1	1	0.1	0.1	1.1
26	1	1	1	0.1	0.1	1.1
27	1	1	1	0.1	0.1	1.1
28	1	1	1	0.1	0.1	1.1
29	1	1	1	0.1	0.1	1.1
30	1	1	1	0.1	0.1	1.1
31	1	1	1	0.1	0.1	1.1
32	1	1	1	0.1	0.1	1.1
33	1	1	1	0.1	0.1	1.1
34	1	1	1	0.1	0.1	1.1
35	1	1	1	0.1	0.1	1.1
36	1	1	1	0.1	0.1	1.1
37	1	1	1	0.1	0.1	1.1
38	1	1	1	0.1	0.1	1.1
39	1	1	1	0.1	0.1	1.1
40	1	1	1	0.1	0.1	1.1
41	1	1	1	0.1	0.1	1.1
42	1	1	1	0.1	0.1	1.1
43	1	1	1	0.1	0.1	1.1
44	1	1	1	0.1	0.1	1.1
45	1	1	1	0.1	0.1	1.1
46	1	1	1	0.1	0.1	1.1
47	1	1	1	0.1	0.1	1.1
48	1	1	1	0.1	0.1	1.1
49	1	1	1	0.1	0.1	1.1
50	1	1	1	0.1	0.1	1.1
51	1	1	1	0.1	0.1	1.1
52	1	1	1	0.1	0.1	1.1
53	1	1	1	0.1	0.1	1.1
54	1	1	1	0.1	0.1	1.1
55	1	1	1	0.1	0.1	1.1
56	1	1	1	0.1	0.1	1.1
57	1	1	1	0.1	0.1	1.1
58	1	1	1	0.1	0.1	1.1
59	1	1	1	0.1	0.1	1.1
60	1	1	1	0.1	0.1	1.1
61	1	1	1	0.1	0.1	1.1
62	1	1	1	0.1	0.1	1.1
63	1	1	1	0.1	0.1	1.1
64	1	1	1	0.1	0.1	1.1
65	1	1	1	0.1	0.1	1.1
66	1	1	1	0.1	0.1	1.1
67	1	1	1	0.1	0.1	1.1
68	1	1	1	0.1	0.1	1.1
69	1	1	1	0.1	0.1	1.1
70	1	1	1	0.1	0.1	1.1
71	1	1	1	0.1	0.1	1.1
72	1	1	1	0.1	0.1	1.1
73	1	1	1	0.1	0.1	1.1
74	1	1	1	0.1	0.1	1.1
75	1	1	1	0.1	0.1	1.1
76	1	1	1	0.1	0.1	1.1
77	1	1	1	0.1	0.1	1.1
78	1	1	1	0.1	0.1	1.1
79	1	1	1	0.1	0.1	1.1
80	1	1	1	0.1	0.1	1.1
81	1	1	1	0.1	0.1	1.1
82	1	1	1	0.1	0.1	1.1
83	1	1	1	0.1	0.1	1.1
84	1	1	1	0.1	0.1	1.1
85	1	1	1	0.1	0.1	1.1
86	1	1	1	0.1	0.1	1.1
87	1	1	1	0.1	0.1	1.1
88	1	1	1	0.1	0.1	1.1
89	1	1	1	0.1	0.1	1.1
90	1	1	1	0.1	0.1	1.1
91	1	1	1	0.1	0.1	1.1
92	1	1	1	0.1	0.1	1.1
93	1	1	1	0.1	0.1	1.1
94	1	1	1	0.1	0.1	1.1
95	1	1	1	0.1	0.1	1.1
96	1	1	1	0.1	0.1	1.1
97	1	1	1	0.1	0.1	1.1
98	1	1	1	0.1	0.1	1.1
99	1	1	1	0.1	0.1	1.1
100	1	1	1	0.1	0.1	1.1

The sections of the duodenum which were selected for comparative histologic study were obtained from the following levels: at or just below the sphincter of Oddi through the middle of the obstruction and a few centimeters below the latter.

In order to determine the amount of hypertrophy of the muscularis of the duodenum above the obstruction comparison was made with the width of the muscularis below the obstruction. In addition, the outer longitudinal and the inner circular muscular layers were measured separately for comparison of the relative hypertrophy of each component. The determinations were made in the following manner: The sections of the intestine were enlarged to a known magnification, measurements were made, and after reducing to scale the results were expressed in terms of millimeters. The measurements were considered to be only relative owing to possible variations in the state of tonus of the intestine at the time of fixation.

[ED COMMENT—We wish to record our agreement with the recommendations of the authors, but we go farther in that we advise the method employing the fascial suture in the repair of acutely fractured patellae as well as in the old ununited fractures. This method has been employed at the Massachusetts General Hospital for from three to four years, and it has been possible to allow motion and use from the start without the necessity of any splinting.]

*Synovectomy in Chronic Arthritis of the Knee Joint*—In cases of chronic infectious arthritis of the knee, when improvement has not been obtained from focal and other methods of treatment, Payr<sup>47</sup> recommended excision of the synovia. He performed this operation in seven cases with satisfactory results. The synovia was found markedly thickened, sometimes to the size of a finger, and contained granulomatous masses, areas of necrosis, and foci of bacteria. Payr felt that there is little danger of ankylosis or of secondary infection.

*Operative Lengthening of the Tibia and Fibula*—Abbott<sup>48</sup> reviewed the work on operative lengthening of the tibia and fibula and described his apparatus for lengthening both bones of the leg. It is modeled somewhat after Putti's apparatus and consists of two steel transfixion pins held in adjustable rods fixed to a Thomas splint in such a way that absolute control of the fragments is obtained. His operation consists of the following steps: (1) lengthening of the Achilles tendon, (2) osteotomy of the fibula, (3) insertion of pins, (4) osteotomy of the tibia, and (5) application of stabilizers and foot-piece. The lengthening is accomplished by a gradual adjustment of the apparatus so that from one-sixteenth to one-eighth inch a day is gained. The stretching is maintained for about three weeks, or until about 2 inches (5 cm) is gained. Of six patients treated, results in five were considered successful by the author, from 1¼ to 1⅞ inches (3.1 to 4.6 cm) having been gained. He pointed out that rigid asepsis must be maintained and that the surgeon who has not the time to make daily mechanical adjustments should not try the method.

[ED COMMENT—The author is employing the operation for lengthening bone not only in cases in which the full length of the limb has previously existed and has been lost, as in the case of malunited fractures, but in cases in which the full length of the limb has never existed, such as in infantile paralysis and old epiphysitis. His work demonstrated that a gain of 2 inches or more can be obtained in such cases without harm. The procedure is fraught with danger, however, from first to last and demands the closest attention from the surgeon.]

47 Payr, E. *München med Wchnschr* 74 1437, 1927.

48 Abbott, LeRoy C. *J Bone & Joint Surg* 9 128 (Jan) 1927.



first metatarsal bone, had been performed, and from a study of the results the authors felt that this procedure involves the risk of causing further spreading of the anterior arch or of producing stiffness in the joint from resulting bony proliferation. The best results were seen in thirty cases in which Ludloff's operation—oblique osteotomy of the first metatarsal bone—had been performed. Even here the results were not entirely satisfactory, and the authors recommended a combination of Ludloff's operation with transplantation of the abductor hallucis. They considered that proper after-treatment is of great importance.

Pick<sup>53</sup> studied a group of 28 patients who were operated on in the city hospital of Dortmund from twelve to fifteen years previously. Of these, 14 were well pleased with the results, 11 were barely satisfied, and 3 were dissatisfied. The best results were seen either after Ludloff's operation (as already described) or after Hohmann's operation, which consisted of a wedge-shaped excision posterior to the head of the first metatarsal bone with transplantation of the abductor hallucis muscle.

Cleveland<sup>54</sup> reported the results of about 200 operations for hallux valgus in 108 patients. Five different types of operation had been employed: (1) simple excision of the exostosis, (2) wedge-shaped osteotomy of the metatarsal with excision of the exostosis (Ludloff's operation), (3) resection of the proximal end of the phalanx with excision of the exostosis (Keller's operation), (4) resection of the metatarsal head with excision of the exostosis (Hueter's operation), and (5) excision of the exostosis with division of the lateral ligaments and of the adductor muscles and realinement of the phalanx on the metatarsal by means of a flap formed from the medial ligament (Silver's operation). The author found that in this series resection of the metatarsal head with removal of the exostosis had given the most satisfactory results. The most important cause of failure of any operation is the presence of chronic arthritis in the joint, and in these cases the results are poor in proportion to the severity of the arthritis. Other causes are a severely impaired anterior arch, inadequate excision of the metatarsal or phalangeal exostoses, and failure to remove loose fragments or bone sand. When the sesamoid bones show hypertrophic changes, they should be removed. Of greatest importance is the selection of an operative procedure that fits the individual case.

[ED NOTE—It is interesting to have these studies of end-results from such widely separated communities. They agree in condemning simple removal of the exostosis. The German reports praise the results

53 Pick, H. *Arch f Orthopaedic*, 1926, vol 35

54 Cleveland, Mather. *Hallux Valgus*, *Arch Surg* 14 1125 (June) 1927



*The Rôle of the Capsule in Contractures of the Joints*—Silver<sup>57</sup> discussed the arrangement of joint capsules and pointed out that from a surgical standpoint one must consider the capsule as including not only the supporting synovial membrane but the ligamentous extensions and bands attached about the joints. He further emphasized that the capsule is largely on the flexor surfaces of the joints. He divided capsular contractures into four types: simple postural, traumatic, inflammatory and trophic. He advocated subperiosteal separation of the capsule by the subcutaneous method for relief of contractures of the fingers, the metacarpophalangeal joints, the wrist, the elbow, the ankle and by the open method at the knee. The incision for the knee is made laterally just in front of the biceps tendon and the capsule is stripped, care being taken to free the capsule in the intercondyloid notch.

*Tendovaginitis Stenosans of the Wrist*—Winterstein<sup>58</sup> gave a detailed description of tendovaginitis stenosis at the styloid process of the radius, stating that the condition is not rare and should be readily recognized. The main symptom is pain at the radial styloid and is due to the narrowing of the tendon sheath containing the tendons of the long and short abductors of the thumb. The pain is increased by movements of the wrist and thumb, and there is local tenderness on pressure. The condition may heal within a few weeks as a result of conservative treatment, but frequently remains obstinate. In such cases prompt relief can be obtained by operation, the sheath being split or a small strip excised.

*Treatment of Ischemic Contraction of Hand*—Johansson<sup>59</sup> reported three advanced cases of ischemic paralysis in which complete functional recovery was obtained by operative treatment. This consisted of the freeing of all the flexor muscles and lengthening of all the flexor tendons. The results were compiled three and one-half, four and four and one-half years after operation.

*Osteitis Deformans Framboesica*—Matsunga<sup>60</sup> reported twenty-four patients with frambesia who showed skeletal changes typical of osteitis deformans.

*Actinomycosis of Bone*—Krogus<sup>61</sup> reported a case of actinomycosis of the tibia without any primary focus elsewhere. The symptoms simulated osteomyelitis, and the diagnosis was not made until three

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57 Silver, David. *J Bone & Joint Surg* **9** 96 (Jan) 1927

58 Winterstein, O. *Munchen med Wchnschr* **74** 13 (Jan 7) 1927

59 Johansson, S. *Acta chir Scandinav* **61** 188 (Dec 22) 1926

60 Matsunga, T. *Acta Dermatologica* **2** 76 (Jan) 1927

61 Krogus, A. *Finska läk-ällsk handl* **69** 1 (Jan) 1927

of round cells varied from occasional small interstitial foci to large abscesses with extensive destruction of the parenchyma, large numbers of polymorphonuclear leukocytes were present in the latter. The proliferation of intertubular connective tissue occurred in the following different forms as linear scars extending through the cortex into the medulla, as large wedge-shaped areas in the cortex suggestive of healing infarcts and as early lesions consisting of a hyperplasia of young fibroblasts with round cell infiltration. In the areas of fibrosis, the tubules were dilated and distorted. Regeneration of tubular epithelium was observed. In two dogs, calcium deposit was present in a few convoluted tubules in which the epithelium was destroyed. The glomeruli were well preserved as a rule, occasionally, round cell infiltration occurred, in a few dogs, some of the glomeruli were completely obliterated by connective tissue, and in one dog calcification was found. Most of the dogs had accumulations of fat in the epithelium of Henle's loops and the proximal portion of the collecting tubules. The blood vessels did not show any changes.

Microscopic examination of the liver, gallbladder and pancreas did not reveal any pathologic changes. Significant changes were not observed in the bone marrow, spleen or lymph nodes. Evidence was not found of arthritic alterations in the joints. In some of the dogs that died with symptoms of ileus, a terminal pneumonia was found.

#### COMMENT ON EXPERIMENTAL RESULTS

Although it was well known that hypertrophy of the intestine occurred above a chronic obstruction, experimental studies concerning the part played by the respective layers of the intestines in this reaction had not been published. Although Herz<sup>1</sup> included some measurements in his work, he did not approach the problem from this point of view. In addition, the duration of the stenosis was too short to draw any conclusions. In the series of dogs which we studied, it was found that the quantitative increase of the inner circular layer of the duodenum was much greater than that of the outer longitudinal layer in the process of hypertrophy. The muscularis mucosae did not partake in the hypertrophy. Hyperplasia of the mucosa occurred, but morphologic changes were not found.

In view of the fact that dogs are subject to naturally acquired chronic nephropathies,<sup>10</sup> the renal lesions which were found in the dogs with chronic duodenal stenosis could not be considered significant. The changes were principally interstitial and may have been due to intercurrent infections or parasites. Evidence of a specific type of lesion



In cases of osteochondritis, the defects in the articular surfaces are clearly shown. Sievers felt that there may be some therapeutic benefit in certain cases from the slow absorption of the oily substance, on the other hand, there is the disadvantage that additional roentgenograms may be indistinct.

[ED COMMENT—Sievers' method would appear to be of value for purposes of research but not for routine clinical investigation.]

*Some Anomalies and Deformities of the Vertebrae*—Hanson<sup>66</sup> made a study of roentgenograms of vertebrae of different ages, beginning with the fetal period. From the latter part of fetal life up to the second year, the body of the vertebra is divided into three plates, the upper and lower ones being dense, with a lighter one between. At the anterior border of the latter, a conelike cavity is seen, with its base forward. Anatomically, this corresponds to a channel in the bone containing bone marrow and a vein, and is not a nutrient foramen, as formerly stated. The cavity disappears at the end of the second year in all except the fifth, sixth and seventh dorsal and first lumbar vertebrae. In these vertebrae the cavities usually disappear at the fourteenth year, but occasionally persist even up to the twenty-fifth year. Hanson believed that the frequency of tuberculous lesions in these vertebrae depends largely on the persistence of the cavities, as they contain many blood vessels. Injection of the nutritive arteries shows that one artery supplies two adjoining vertebrae, and this may account for the frequent involvement of the adjacent vertebrae by a tuberculous process.

#### FRACTURES

*Leukocytosis Accompanying Fractures*—Walton<sup>67</sup> made a study of the occurrence of leukocytosis in 260 patients with fracture and drew the following conclusions. Traumatic injury of bone gives rise to a moderate leukocytosis, which is chiefly polymorphonuclear in type. The increase in white cells reaches a maximum within twenty-four hours following the injury and remains approximately at this level until immobilization of the fragments is secured. Reduction and immobilization are followed by a rapid fall in the white cells, with a return to normal at the end of the fifth or sixth day. Old, debilitated persons usually develop less leukocytic reaction than do children or young adults. The increase in the number of white cells appears to be largely the result of injury to the bone and periosteum but varies also in proportion to the amount of injury of the soft tissues and displacement of fragments.

<sup>66</sup> Hanson, R. *Acta chir Scandinav* 60 309, 1926.

<sup>67</sup> Walton, Ralph W. *Leukocytosis Accompanying Fractures*, J A M A 88 1138 (April 9) 1927.

# STUDIES IN INTESTINAL OBSTRUCTION

I A COMPARISON OF THE TOXICITY OF NORMAL AND OBSTRUCTED INTESTINAL CONTENT \*

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AND

STANLEY S CHUNN, M B

MINNEAPOLIS

Most clinicians and investigators agree that death in acute intestinal obstruction is due to the absorption of some toxic element from the bowel above the point of obstruction. Much experimental work in the field of intestinal obstruction has been done by American investigators, and it is generally conceded by them that the normal intestinal contents are relatively nontoxic, but that, with the advent of obstruction, a very toxic substance is formed.

Stone, who has done considerable experimental work in this field, states in a recent review<sup>2</sup> that death from intestinal obstruction is due to a toxemia, and that the toxin has its origin in protein decomposition in the obstructed bowel. He says that even after obstruction to the continuity of the bowel has been established, a definite interval of time intervenes before the fluid shows definite evidence of toxicity.<sup>2</sup> From ten to twenty hours usually elapse, according to Stone<sup>2</sup> and Braeye,<sup>3</sup> after the break in the continuity of the intestinal canal has occurred before much fluid accumulates above the obstruction, and thirty-six hours before the fluid shows marked evidence of toxicity. Van Beuren<sup>4</sup> concluded that an interval of forty-eight hours followed obstruction in dogs before the toxic substance accumulated above the point of obstruction. No definite statement appears in the work of many investigators relative to the time interval necessary for the development of this toxic material. But in the light of the intoxication theory which claims most investigators as its adherents, the death of the animal following experi-

\* From the Department of Surgery of the University of Minnesota

\* Presented before the Minnesota Pathological Society, Minneapolis

1 Stone, H B, Bernheim, B M, and Whipple, G H. Intestinal Obstruction. A Study of the Toxic Factors, Bull Johns Hopkins Hosp 23 159, 1912

2 Stone, H B. The Toxic Agents Developed in the Course of Acute Intestinal Obstruction and Their Action, Surg Gynec & Obst 32 415, 1921

3 Braeye, Louis. On the Formation of the Toxic Fluid Found in Isolated Intestinal Obstruction, Am J Surg 1 282, 1926

4 Van Beuren, F T. Enterostomy in Acute Ileus. The Time Element. A Preliminary Report, Am J Surg 1 284, 1926

vertebrae, Kennedy<sup>70</sup> concluded that such injuries are not rare, that the cause is usually direct violence and that the fractures are frequently multiple. He believed that the fracture is negligible and that the disability is largely due to the associated sprain or contusion. Definite bony union is obtained in some of the cases. Disability lasting longer than six months is out of the ordinary, and the majority of the patients should be back at work within two months, practically without complaints referable to the injury.

## RESEARCH

*Physiologic Study of the Blood Supply of the Diaphysis*—Johnson<sup>71</sup> carried out a well conceived series of experiments to show the relative importance of the different sources of blood supply of the diaphysis. He studied the rate and character of repair in drill hole defects of the cortex in the bones of dogs, under the following conditions: (1) with the nutrient artery intact and all other sources of blood supply cut off, (2) with the metaphyseal vessels alone intact and (3) with the periosteal blood supply alone intact. Specimens have been obtained from the different animals at different periods and the reparative process followed. From these experiments, Johnson concluded that the nutrient vessels maintain nutrition throughout the medulla and the inner half of the cortex. Repair is active when the blood supply of the bone is derived from these vessels. The metaphyseal vessels supply the medulla and the inner half of the cortex. With the blood supply from other sources cut off and these vessels alone intact, repair is active but not so active as with the nutrient vessels. The periosteal vessels do not supply more than the outer half of the cortex. With blood supplied by these vessels alone, repair is greatly delayed and its character altered. Thus the nutrient vessels are the most important, the metaphyseal vessels next, and the periosteal blood supply the least important.

*Regeneration of the Synovia*—Wolcott<sup>72</sup> performed experimental synovectomy on the joints of dogs. The animals had been killed at periods ranging from 1 to 108 days and the joints studied. Gross examination, roentgenologic study of the joints injected with sodium iodide, and microscopic investigation showed the formation of a new synovial layer and the restoration of a practically normal joint pouch within 108 days. The newly formed membrane is produced by metaplasia of the connective tissue, and when the membrane has been formed this process is inhibited.

70 Kennedy, Robert H. *Ann Surg* 85 519 (April) 1927

71 Johnson, Robert W. *J Bone & Joint Surg* 9 153 (Jan) 1927

72 Wolcott, W. Eugene. *J Bone & Joint Surg* 9 67 (Jan) 1927

opinion Ellis,<sup>12</sup> Eisberg,<sup>13</sup> Draper<sup>14</sup> (Draper-Maury) and Sweet, Peet and Hendrix<sup>15</sup> believed that the toxic factor responsible for death in intestinal obstruction is allied to the toxemia of pancreatitis. Comparisons were made in this study between the toxicity of the normal intestinal contents and the contents of the bowel in animals with intestinal obstruction. Comparisons were made of the toxicity of the intestinal contents above and below the point of obstruction. The dog and the rabbit were used in this study.

# METHOD

The method employed in collecting the fluid from the bowel was as follows. In the normal animal, the entire content from the stomach to the cecum was pressed into a container by milking the bowel through the gloved fingers. In none of the experiments was the toxicity of the content of the large bowel determined. In the animals with intestinal obstruction, the material from above and below the point of obstruction was collected separately. Obstruction was created in the animals by either severing and turning in the ends of the intestine or by simple ligation of the intestine with gauze from about 20 to 30 cm beyond the pylorus. This procedure was carried out under aseptic technic and ether anesthesia. The animals were killed when their condition was considered serious, usually from two to three days following the artificial obstruction, in a few instances, the content of the bowel was obtained shortly after the natural death of the animal. In a few dogs closed loop obstruction was performed with and without restoration of the continuity of the intestine. In a few of these, the fluid in the obstructed loop was drained out through a catheter inserted into the bowel. In one instance, the contents of a severed gut obstruction were drained out through a gastrostomy tube.

The intestinal contents obtained in each instance were diluted with an equal amount of physiologic sodium chloride solution. The contents were filtered twice through filter paper under suction. The filtrate was then run through a coarse and a fine Berkefeld filter,<sup>16</sup> and cultures were made to ascertain the sterility of the fluid. The filtration process was started directly after the contents were collected. When injections were made from the same contents on successive days, they were kept in the icebox in the interim. In the instances in which intravenous injections were made in dogs, hemolysis tests were made with the blood of the dog to be certain that the fluid was not hypotonic. The injected material was then clear, often colorless and sterile. The injections were made into the vein on the outer aspect of the dog's leg without anesthesia. Seventeen normal

- 12 Ellis, J W The Cause of Death in High Intestinal Obstruction, Ann Surg 75 429 (April) 1922
- 13 Eisburg, H B Experimental Intestinal Obstruction, A Study in Severed Gut Obstruction and Segmental Obstruction, Ann Surg 74 584, 1921
- 14 Draper, J W (footnote 5, third reference)
- 15 Sweet, J E, Peet, Max M, and Hendrix, B M High Intestinal Stasis, Ann Surg 63 720 (June) 1916
- 16 No injections were made with boiled or heated intestinal content nor was any attempt made to determine the toxicity of portions soluble in or precipitated by alcohol

the process of absorption soon increased and surpassed it. When the bone was implanted in the marrow cavity, it occasionally healed in place, but in the end it was absorbed and the marrow space reestablished. Only when the bone was implanted on bone did firm consolidation and union of the transplant with the recipient tissue take place. An actual metaplasia of connective tissue into real bone has been seen by the author following transplantation of fine splinters of bone into the soft tissues. Ten days after the transplantation, the splinters were surrounded by a thick layer of osteoid tissue.

injection In three instances, death occurred from twenty minutes to an hour following injection and in two instances, about two hours following injection The others died during the night

Of the thirty rats injected with the intestinal contents of the rabbit, fifteen were injected with material obtained from two normal rabbits, and the other fifteen were injected with material from the two rabbits in which intestinal obstruction had been established by tying off the terminal ileum with gauze two days previously Five rats injected with the intestinal contents of the normal rabbit and three injected with the contents of the obstructed bowel died All the animals were ill Ataxia and clonic spasms and convulsions were frequently noted The more paralytic and convulsive effect of rabbits' intestinal contents was noted in these injections One of the rats injected with normal intestinal contents that recovered was rigid with clonic contractions two minutes after injection Another, also injected with normal intestinal contents

TABLE 3—*Rats Injected Intraperitoneally with the Intestinal Contents of the Rabbit*

	Number Injected	Average Amount Injected, Cc	Sick	Ataxic	Clonic Spasms	Para- lytic	Coma- tose	Died	Recovery
Normal	15	6	15	9	6	4	7	5	10
Obstructed	15	7	15	10	4	2	5	3	12

was ataxic and appeared completely paralyzed three minutes after injection For a long time the rat lay on his back with flaccid extremities, but it recovered One rabbit injected with the contents of the obstructed bowel died one minute after injection Several rats died two and three minutes following injection The susceptibility of the rat to the injected intestinal fluids did not always vary directly with the amount used nor inversely with the weight of the animal Instances occurred in which 3 cc of a given intestinal content killed a fairly large rat when 6 or 7 cc failed to kill a much smaller one Postmortem examinations were performed on all the rats that died to rule out puncture of a vessel with consequent hemorrhage as the cause of death Hemorrhage was not observed in any instance

Many of the rats that survived injection were re injected on subsequent days and appeared to have developed an increased tolerance to intestinal contents We believe that this observation does not have any immunologic significance in treatment for obstruction, but only means that repeated injections of the same protein into the animal increases its tolerance

The results obtained in these experiments, though at variance with the statements of most investigators in this field are not without

(b) Localized violence that occurs when an object with a limited area of impact comes in contact with the anterior abdominal wall. Examples of this type include kicks by horses, kicks with the foot, stamping on the body, blows with fist or stick and thrusts with a wagon pole.

The abdominal injuries themselves are separated into the following groups

1 Injuries of the parenchymatous abdominal viscera, which are represented by the liver, spleen, kidney and pancreas

2 Injuries of the hollow abdominal viscera, which include the stomach, the intestines and their mesenteries and the urinary bladder

### INJURIES OF THE PARENCHYMATOUS ABDOMINAL VISCERA

The parenchymatous organs lie in the upper part of the abdomen and are more or less protected by their deep position or by the lower ribs and the lumbar spinal column. In the vast majority of cases, they are injured only by a severe grade of violence. Exceptions occur, which will be noted later. The usual results of the injury are marked shock and profuse internal hemorrhage, which is frequently fatal.

A severe generalized trauma sometimes causes multiple ruptures of the abdominal and thoracic viscera, fractures of the ribs, spine and sternum, and other lesions. Reports of a large number of such cases were found among the records obtained at necropsy, as death occurred almost immediately after the accident, it was felt that little was to be gained from any prolonged study of this material. A general statistical survey was not undertaken for this reason, and only selected cases which illustrate characteristically the clinical and anatomic features of the different injuries are presented.

#### LIVER

Of all the abdominal viscera, the liver is the one most commonly ruptured by nonpenetrating blunt force. Geill<sup>1</sup> estimated that such ruptures occurred in 59.9 per cent of all injuries of the trunk, and others accept his figures as substantially correct.

The anatomic characteristics of the organ explain its susceptibility to trauma. It has a closely knit structure, which is only slightly elastic, and so cannot sustain a marked alteration in form without a break in continuity. It occupies the entire thickness of the right hypochondrium and is partly protected by the lower right ribs. Ligaments attach the liver to the surrounding structures in such a way that its range of motion in any direction is more or less limited. Any force applied to the right side of the upper part of the abdomen, if intense enough, will cause a rupture, as the liver cannot easily escape the effects of the violence. The types of trauma usually described are such severe forms

<sup>1</sup> Geill, C. Vrtljschr f gerichtl Med 18 205 1899

and the dogs given subcutaneous injections of saline solution. Three days later, when, if saline had not been given the animals probably would have been dead, the intestinal contents both from above and below the point of obstruction were collected and prepared as outlined. Twelve rats given these injections, six with the contents from above and six with the contents from below the obstruction, were ill. Two appeared moribund about an hour after injection, one of these was injected with intestinal contents from above, the other with contents from below the obstruction. The next morning, however, they all seemed active again.

Six rats were then injected with the contents obtained from the intestine of a normal dog diluted with an equal amount of saline. Simple suction filtration alone was employed, the Berkefeld filtration being omitted. All the rats were ill and died a few hours after the injections. Six rats were injected with intestinal contents obtained from a normal rabbit prepared in the same manner. The rats were all ill shortly following the injections and died from its effects.

Such a result, we feel, is to be anticipated because Berkefeld filtration must remove toxic substances.

#### SUMMARY

The intestinal contents of several normal dogs and rabbits and dogs and rabbits with intestinal obstruction were collected and subjected to Berkefeld filtration. Intravenous injections of the material obtained from the intestine of normal dogs and from dogs with intestinal obstruction were given to normal healthy dogs. Intraperitoneal injections of rats were made from the intestinal contents of both normal dogs and rabbits and dogs and rabbits with intestinal obstruction. Seventeen dogs were injected with the intestinal contents of dogs prepared in this fashion, two died. In both instances, the contents obtained from the intestine of normal dogs was used. Thirty-six intraperitoneal injections of the intestinal contents of the dog were made into rats, eleven deaths resulted. In one instance each, death was due to the injection of the contents of normal and of obstructed loops. The other nine deaths were caused by the injection of intestinal contents obtained from below the point of obstruction into dogs with severed gut obstructions. Thirty rats were injected intraperitoneally with the intestinal contents of the rabbit. Following the injection of fifteen rats with the normal intestinal contents of the rabbit, five died. Of fifteen rats injected with the contents of the obstructed bowel three died. All the rats that were given injections were ill. The intestinal contents both from above and from below the obstruction in dogs that had been given saline solution subcutaneously was toxic on injection.



the liver will be driven upward into the funnel shaped lower part of the chest, which will distort and break it in the manner described

Under other conditions, falls from a height are supposed to result in the production of sagittal tears of the concave surface. According to Walz and Holle,<sup>5</sup> a fall on the head or shoulders with the lungs in full inspiration will cause the glottis to close spasmodically, it will flatten the diaphragm and keep the liver from entering the chest. The under surface is forced to bulge away from the diaphragm at the moment of impact and thus is ruptured. Falls on the feet or buttocks are also supposed to produce the same result, the diaphragm is flattened on the recoil, and the concave surface bulges downward and sometimes ruptures. During this kind of fall, the ligaments of the liver are not stretched, according to Walz and Holle,<sup>5</sup> and have little or nothing to do in the production of the lesion.

In some instances, a violent trauma which acts tangentially on the epigastrium in an upward direction will force the anterior edge of the left lobe toward the diaphragm. This movement will tear the anterior portion of the concave surface. The point most often involved is the furrow that contains the round ligament.

Sometimes violence applied directly against the front portion of the liver will crush the organ between the anterior abdominal wall and the projecting edge of the vertebral bodies. A complete sagittal rupture at the junction between the right and left lobes is the result. This sort of injury was present in a case of homicide, the abdomen had been stamped on as the woman lay on her back.

Transverse and oblique ruptures are found on both the upper and the under surfaces of the liver. They are due to pressure exerted on the anterior edge in a backward direction. Bending occurs in such a way that the sagittal diameter is shortened and the upper or under surface is rendered acutely convex, which produces the corresponding tears. They are not so common as the sagittal ruptures. The same violence is also supposed to drive the posterior portion of the right lobe against the vertebral column and cause a laceration of the liver in this region. The name of "contrecoup rupture" has been given to this injury, because it occurs at a point opposite the place at which the force is applied.

A common rupture is the craterous laceration found on the upper surface of the right lobe near the coronary ligament. It may be produced by a lateral compression which fractures the right lower ribs and forces them against the parenchyma in such a way as to cause a tear. The sharp ends of the broken ribs may pierce the liver by penetrating the diaphragm, though this complication is rare. The lesion also may be the result of a severe localized violence, such as a kick by a horse, which directly lacerates the organ.

# THIRTY-FOURTH REPORT OF PROGRESS IN ORTHOPEDIC SURGERY\*

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LOUVAIN, BELGIUM

*Concluded from page 168*

## OPERATIONS ON THE BONES, JOINTS AND TENDONS

*Tendon Transplantation for Paralysis of the Opponens Muscle of the Thumb*—Weil<sup>39</sup> used Book's method of tendon transplantation for paralysis of the opponens muscle of the hand and warmly recommended it. The operation consists in transplantation of the extensor of the fifth finger. An incision is made over the dorsum of the fifth metacarpal bone, and the extensor tendons exposed. The extensor minimi digiti is the tendon lying nearest to the ulnar border of the hand. This is freed and divided at the level of the metacarpal head. A second incision is made over the outer side of the first metacarpal bone. The freed tendon is then passed subcutaneously around the wrist and across under the palmar surface to the first metacarpal, to which it is fixed. The thumb is splinted in the opposed position for twelve days after which exercises and muscle training are started.

*Remote Results of Resections of the Elbow*—Senecque<sup>40</sup> summarized the results of an investigation by Comte on the remote results of resections of the elbow by the method of Ollier for tuberculosis and conditions of ankylosis, which were published as These Lyon in 1926. These results were

1 Resections for Tuberculosis. End-results were obtained in 55 patients who had been operated on by Ollier. The time that the

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\* This Report of Progress is based on a review of 166 articles selected from 419 titles dealing with orthopedic surgery appearing in medical literature between March 12, 1927, and July 2, 1927. Only those papers that represent progress have been selected for note and comment.

39 Weil S. Klin. Wchnschr. 5: 650 (April) 1929.

40 Senecque. Presse med. 34: 1351 (Oct. 27) 1924.

chyma Bile may also be present in small quantities from the tearing of branches of the bile duct After a few hours, the peritoneal hemorrhage turns dark red and later brownish red These changes cause irritation, pigmented brown fibrin is deposited on the serous surface and a low grade peritonitis results If bacteria gain entrance in some way, either from an injury to a hollow abdominal viscus or through a laparotomy wound, a real infective and suppurative peritonitis will develop

Occasionally some of the hemorrhage from the rupture may enter the extraperitoneal tissues in larger or smaller amounts, especially if the lesion opens into these structures Accordingly, retroperitoneal hematomas of varying size are sometimes found near the diaphragm and the lumbar fossa One such case occurred in the material obtained at necropsy

The most rapidly fatal hemorrhages are generally associated with complete sagittal ruptures of the liver Of twelve injuries of the liver that caused death either immediately or within five hours, nine were of this type In rare instances, however, lesions even of this sort may undergo spontaneous healing (Chiari)<sup>10</sup>

The huge craterous lacerations near the coronary ligament may also bleed rapidly, especially if some large intrahepatic vessel is torn On the other hand, the less extensive lesions show slower bleeding, and blood clots tend to adhere to the laceration If the patient lives, thromboses are formed in the torn blood vessels and bile ducts, organization tends to occur, and healing by scar tissue is the result If the laceration is deep, the edges are deprived of their requisite blood supply and within about twenty-four hours become yellowish white and necrotic, forming the so-called traumatic infarct<sup>11</sup> (fig 1) Under ordinary conditions these areas are absorbed, but a large piece may become separated from the liver tissue and act as a sequestrum Occasionally it is enclosed in a cavity formed by adhesions of the rupture to the surrounding structures, and later undergoes transformation into a true abscess (Fertig<sup>12</sup> and Biernath)<sup>13</sup> The process is slow, and takes months for its completion

The central ruptures of the liver do not bleed into the abdominal cavity and, unless death occurs from the primary shock, complications develop slowly In some instances the hemorrhage in the substance of the liver may cause a large swelling in the upper part of the abdomen and enough disturbance to justify operative intervention for this reason alone<sup>6</sup> Small ruptures tend to heal with the formation of central scars, others, a trifle larger, develop traumatic infarcts and

10 Chiari, H Berl klin Wchnschr **45** 1629 (Sept 7) 1908

11 Orth, J Deutsche path Gesellsch Verhandl **3** 82, 1901

12 Fertig, J Deutsche Ztschr f Chir **87** 87, 1907

13 Biernath, P Arch f klin Chir **90** 73, 1909

resection was more or less abandoned by American surgeons because of the flail, unstable condition that so frequently resulted. Perhaps this was due to a failure to employ Ollier's careful superosteal method of dissection. Ollier was a pioneer in operations on the bones and joints and made real contributions to the subject. The report is doubly interesting in that the evidence obtained from a study of Comtes results substantiates his reputation as a master surgeon.]

*Transplantation for Paralysis of the Serratus Magnus*—Riedel<sup>41</sup> reported a new method of transplantation of muscle which he employed for paralysis of the serratus magnus muscle with good results. An incision is made extending from the spinal column to the outer edge of the scapula and the latissimus dorsi muscle exposed. The outer half of the muscle is separated from the inner half and its tendinous portion divided. This is then passed under the inner portion of the muscle and pulled through to the lower corner of the inner border of the scapula. The lower part of the muscle is fixed to the sixth, seventh and eighth ribs. In this way, the transplanted muscle is made to act as a muscular ligament for the support of the scapula, it prevents it from sliding off the trunk and permits fair function for the arm.

[ED COMMENT—We should want to be convinced that the actions of two different parts of the same muscle can be successfully dissociated before employing this operation.]

*Operation on the Hip*—Writing on reconstructive operations on the hip joint, Brackett<sup>42</sup> said that there are three conditions in which opinion differs as to the choice of procedure. 1. In old tuberculous disease, he believed that an operation causing ankylosis offers the only true solution. 2. From the clinical standpoint, he divided patients with osteo-arthritis into three groups: those who have the potentiality of continued function, those who have little, and those with pain and invalidism. In the first group, operation is not necessary. In the second group the better course seems to be to produce a firm joint which gives stability and relief from pain. In the third group, an operation of stabilization is a matter of convenience to the patient. 3. In old ununited fractures of the hip, the factors to be considered in determining the kind of operation are the degree of atrophy and the size of the remaining portion of the head of the bone, the contour of the head, the appearance of space around the joint, and the presence or absence of osteo-arthritic changes. In these cases, the neck of the femur has practically always disappeared. When the roentgenologic examination gives evidence that the remaining portion of the central fragment is in a condition for performing perfect union,

41 Riedel, G. *Zentralbl. f. Chir.* 54: 578 (March 5) 1927.

42 Brackett E. G. *Am. J. Surg.* 2: 216 (March) 1927.

Thrombosis of the portal vein has been described as the result of an injury. The trauma in some way injures the wall of the vessels, either by a dislocation of the contiguous organs or by direct contusion of the vessel against the spinal column. The thrombosis in time occludes the vein and later, by organization, turns the vessel into a solid fibrous cord. The usual complications are esophageal varices, ascites and similar conditions, all of which are referable to the portal obstruction (Thorel)<sup>15</sup>

Ruptures of the hepatic artery are rare and are found only with the more severe grades of trauma. Just<sup>16</sup> recorded a case of multiple injuries in the upper part of the abdomen in which the cause of death was a delayed hemorrhage from an accessory branch of the hepatic artery which was thought to have been eroded by gastric secretion from a nearby injury to the wall of the stomach.

Ruptures of the biliary system occasionally occur. Any portion of the tract may suffer from the violence. In his analysis of sixty cases from the literature, Lewerenz<sup>17</sup> catalogued the ruptures as follows: gallbladder, 23, intrahepatic bile ducts, 8, common bile duct, 9, hepatic ducts outside the liver, 6, cystic duct, 1 and location of lesion uncertain, 13.

The mechanism of the injury varies with the part of the tract affected. The gallbladder may at times be traumatized by severe violence, or it may be ruptured by a comparatively slight force which compresses the organ and causes it to burst by a hydraulic action. This is especially prone to occur if the wall is diseased or if a marked grade of cholelithiasis is present. Ruptures of the liver are only occasionally associated with this injury.

Three methods of rupture have been made responsible for the lesions of the common bile duct and the extrahepatic branches of the hepatic ducts.

A hydraulic bursting mechanism is said to operate in a few cases. Some of the ducts are probably lacerated by being crushed against the vertebral column. Most of them, however, are undoubtedly the result of a tearing force, the anterior edge of the liver is forcibly elevated toward the diaphragm, and the ducts are, as a consequence, put under tension. A complete or partial break is prone to occur near the pancreas, especially as the common duct is firmly attached to that organ and has a wall of limited elasticity. These ruptures are found mostly in children and young people who have an elastic and easily

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15 Thorel. *Ergebn d allg Path* **18** 123, 1915

16 Just, E. *Arch f klin Chir* **140** 518, 1926

17 Lewerenz. *Arch f klin Chir* **71** 111, 1903

An incision is next made over the lateral aspect of the thigh from the tip of the trochanter to 1 inch above the level of the patella, exposing the tensor fasciae latae and the fascia lata. The tensor is freed as in Legg's operation, but the incisions in the fascia are carried down the leg as far as the incision in the skin extends in order to form a long flap of fascia 1 inch wide. A hole is drilled through the femur just below the neck at the level of the gluteus maximus tendon, and the long flap of fascia is drawn through the hole from before, backward. At that point the edges of the fascia are sutured to the gluteus maximus tendon. The free end of the fascial flap is then drawn up under the gluteal fascia to the lower angle of the first incision, care being taken to keep the gliding surface of the fascia next to the iliac bone. The free end of the erector spinae muscle is laid on top of the fascial flap which had been scarified so that they overlap 2 or 3 inches, and then the edges of the fascial flap and the aponeurosis of the erector spinae muscle are sutured under moderate tension, thus, extension of the tendon is made from the erector spinae muscle to the femur. The leg is put up in a long plaster spica.

Since July, 1926, the author has not bored the transverse hole below the trochanter for the purpose of inserting the fascia, especially in those cases in which power is absent in the tensor fasciae latae, his technic consisted of dissecting the strip of fascia up to the insertion of the gluteus maximus tendon, and then following out the technic already described in passing the tendon up over the buttocks. Indications for the operation are (1) paralysis of the gluteus maximus muscle, (2) paralytic dislocation of the hip, and (3) flexion deformity of the hip when associated with paralysis of the gluteus maximus.

*Late Repair of Fractures of the Patella and of Rupture of the Ligamentum Patellae and Quadriceps Tendon*—Gallie and LeMesurier<sup>46</sup> described in detail operations for the repair of the conditions already mentioned. They pointed out that while these injuries frequently heal solidly and appear firm within a few weeks in a certain number the scar may begin to weaken and stretch so that after a year all power of extension has gone. Repair is accomplished in the case of injury of the patellar tendon by taking heavy transplants from the Achilles tendon and passing them through the patella to the tibial tubercle. In the case of ununited fractures of the patella, fascial strips are used when the bone fragments can be approximated, but transplants from the Achilles tendon are used when a gap remains. In all patients with a ruptured quadriceps tendon, whether the ruptures have occurred early or late Gallie and LeMesurier advocate repair by the use of fascial suture.

<sup>46</sup> Gallie, W. E. and LeMesurier, A. P. *J. Bone Joint Surg.* 9:47 (Jan.) 1927.

The source of the peritoneal fluid was a small sagittal laceration of the under surface of the liver, which was in the furrow in which the round ligament usually lay and ran into the hilum, communicating with a transverse tear of the large left intrahepatic bile duct. The gall-bladder and the rest of the biliary tract were collapsed and free from bile.

It is evident that the rupture excreted much bile from the start and that, in the first few days after the trauma, most of this was absorbed and jaundice was produced. Later, the bile caused a nonseptic peritonitis from the chemical irritation, with the formation of an enormous fibrinous exudate, which blocked the pathway of absorption from the serous surface. This condition resulted in the ascites in which the abdominal cavity was filled with bile and the disappearance of the icterus elsewhere. The entire process is a slow one and, though not septic, is marked by much toxic action. Unless means are taken to close the ruptured duct, the continued excretion of bile will inevitably prove fatal. Cases described by Lewerenz,<sup>17</sup> Stierlin<sup>18</sup> and Hildebrandt<sup>19</sup> give practically the same picture.

In the material obtained at necropsy at the Medical Examiner's Office, protocols of twenty-one cases were collected in which there was a rupture of the liver not complicated by another injury of a fatal nature. A study of these cases brought out some interesting points. The causes of the casualties are listed in table 1. Except in a few instances the trauma was severe.

The age incidence (table 2) did not show anything significant.

A consideration of the causes of death in connection with the lesion in the liver and the length of time the patient survived the accident established the following facts:

1 Seven patients died at the scene of the accident. Of these, four showed a complete sagittal laceration of the substance of the liver and two a huge craterous tear on the upper surface of the right lobe. The six patients died of profuse intra-abdominal hemorrhage. The seventh showed some superficial lacerations on the upper surface, lost only a small amount of blood, and evidently died of the shock of the injury combined with a state of acute alcoholism.

2 Eight patients survived the injury from one-half hour to six hours. Five of these sustained complete sagittal ruptures and died of severe intra-abdominal hemorrhage. One craterous laceration of the right lobe and two superficial lacerations of the surface of the liver were found. These patients died of a combination of shock and acute alcoholism.

3 Two patients survived from twelve to twenty-four hours. Both sustained moderately large craterous lacerations of the upper lobe and

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19 Hildebrandt Arch f klin Chir 81 646 1906

It should not be undertaken until the technic has been acquired by actual observation of Abbott's methods.]

*A Plastic Operation on the Foot*—Miller<sup>49</sup> described a new operation on the foot which he applied to patients with adolescent relaxed feet which do not respond to the usual conservative measures. The operation consists of a plastic transplant of the insertion of the calcaneo-scapoid ligament to the first cuneiform and metatarsal together with arthrodesis of the scaphoid-cuneiform and cuneiform-first metatarsal joints, and occasionally resection of the neck of the astragalus. He also lengthened the Achilles tendon. Plaster is worn for six weeks, after which an adducting shoe with the Thomas heel is worn. The author reported satisfactory results in sixteen cases.

*Flatfoot and Its Treatment*—Von Ditttrich<sup>50</sup> reported the results of Mueller's operation in twenty-five patients with severe flatfoot. Mueller's operation consists in drilling a hole through the tarsal scaphoid and pulling the tendon of the anterior tibial muscle, or a part of it, through that hole. The results have been satisfactory. In the author's opinion more extensive operations ought not to be employed unless repeated manipulation has demonstrated the impossibility of correcting the position of the foot and hence the necessity of an operation on the bony structures.

*Talipes Cavus*—Rugh,<sup>51</sup> who felt that contracture of the plantar fascia is the primary cause of pes cavus and the cause of relapse and of continued progression of the deformity, advised operative excision of the plantar fascia and its replacement by the transplantation of fat tissue that does not contract. After observation of the results of this procedure over a period of four years, he was convinced that it is possible to prevent contraction of the scar by this method and that it does not lead to sagging of the plantar arch.

[ED COMMENT—This would appear to be a radical method for accomplishing the same result that is obtained by stripping the plantar ligaments from the os calcis.]

*Results of Operation for Hallux Valgus*—Mau and Lauber<sup>52</sup> examined a group of patients who had been operated on for hallux valgus at the surgical clinic in Kiel to determine the end-results. In fifteen cases the operation had consisted of the simple excision of the excoriation; the results were generally unsatisfactory. In twenty-nine cases Hueter's operation which consists of resection of the head of the

49 Miller Oscar Lee. J Bone & Joint Surg. 9:84 (Jan.) 1927.

50 Von Ditttrich K. Deutsche Zeitschr. f. Chir. 196:164, 192.

51 Rugh, J. T. Am. J. Surg. 2:707 (April) 1927.

52 Mau C. and Lauber H. J. Deutsche Zeitschr. f. Chir. 197:71, 192.



tried Unfortunately, the clinical histories obtainable were too brief to indicate the reasons for the surgeon's judgment

Nine clinical records which showed the results of the laparotomy were collected They are as follows

#### CLINICAL HISTORIES

CASE 1—A girl, aged 18, was run over by an automobile She was delirious and in a state of shock but not comatose when she was admitted to the hospital A laparotomy was performed shortly after admission A sagittal laceration of the midportion of the liver was found, this was packed with gauze She died three hours later, the cause of death being abdominal hemorrhage

CASE 2—A boy, aged 13, was run over by an automobile He was admitted to the hospital in shock and was pale, with a rigid abdomen, especially in the region of the liver Some of the lower ribs on the right side were fractured A laparotomy was performed a few hours later A large, irregular laceration on the superior surface of the liver was found and was packed with gauze, the abdominal cavity was full of blood Death occurred seven hours after the injury from abdominal hemorrhage At necropsy, a ruptured spleen was discovered

CASE 3—A man, aged 26, fell from a wagon Immediately after the fall he got up, walked a block and then fainted When he was admitted he was alcoholic, pale and in shock, with a rigid and tender abdomen, especially in the upper right portion He also complained of pain in the right shoulder A laparotomy was performed eight hours after the injury and a craterous rupture of the right lobe was found, which was packed with gauze He died thirteen hours after the injury from abdominal hemorrhage

CASE 4—A man, aged 24, was struck by a board thrown from a saw, he was knocked down but was not unconscious On admission, he was in shock and was cold, anemic and vomiting Pain was noticed in the region of the liver and an abrasion was present over the right side of the chest A laparotomy was performed eight hours after the injury A sagittal tear between the liver lobes was found, which was packed with gauze The patient died twenty-four hours after the injury from internal hemorrhage

CASE 5—A boy, aged 13, was struck by an automobile He was not unconscious after the accident, but, on admission, was dyspneic, cyanotic and in a state of shock Fractures of the sixth to ninth ribs on the right side were found A laparotomy was performed a few hours after the accident The liver was torn from the diaphragm, leaving a lacerated surface of the upper portion of the right lobe This was packed with gauze The patient died two and one-half days later in sudden collapse He had a slow abdominal hemorrhage from the injury

CASE 6—A girl, aged 13, fell on a rail fence She vomited and walked about four city blocks to her residence Her condition for four days subsequent to the injury was not alarming She began to complain of constant pain over the region of the liver, and her mother noticed that she was becoming somewhat icteric She was admitted to the hospital four days later, and an abdominal operation was performed the same day An area of liver was found attached to the diaphragm, separated from the rest of the organ This was packed with gauze The blood in the abdominal cavity was evacuated, and the patient recovered in forty-five days A sinus in the operative scar per-

of Ludloff's operation, while the American report favors Hueter's procedure. Studies of end-results are often disappointing in that they fail to provide any basis for generalizations. If we were to draw any conclusion from these reports, it would probably be to the effect that the method of operation is of less importance than the skill with which it is performed and the care that is employed in the after-treatment. It is also important to suit the operation to the individual especially with reference to age.]

## MISCELLANEOUS

*Sprain of Cervical Spine Causing Thrombosis of Anterior Spinal Artery*—Discussing the mechanism of vertebral sprains in the cervical region, Grinker and Guy<sup>55</sup> pointed out that as a result of trauma transitory derangement of the normal relationship of one vertebra to another may occur, the vertebrae quickly returning to normal alignment. This is accompanied by a stretching and laceration of the spinal ligaments. Only when the vertebrae do not return to their original relationship is the condition recognized as a luxation. Greuber reported with necropsy, an example of vertebral sprain due to excessive muscular exertion which produced thrombosis of a portion of the anterior spinal artery in the cervical region and which was followed by softening of the cord in the region supplied by the artery. The authors concluded that temporary vertebral luxations may occur and give rise to lesions of the cord without any evidence by roentgenologic examination of vertebral displacement.

[ED COMMENT—This case is important as an example of the actual pathologic process that may underlie some of the cases of obscure injury of the back.]

*Rupture of the Supraspinatus Tendon*—Although admitting that he has never performed an early operation on or seen a patient with rupture of the supraspinatus tendon soon after injury, Codman<sup>56</sup> advocated early operations for exploration when the lesion is suspected. He based this advice on his own experience of finding at operation that the tendon had been ruptured in many of the old traumatic shoulder. He estimated that this lesion makes up a third of injuries of the shoulders. The signs of the lesion are inability to abduct the arm actively, a slight jog in the motion of passive abduction and to "creak" and soft crepitus beneath the acromion anteriorly. Codman approached the shoulder in the majority of his cases through a split deltoid incision but extended this into the saber cut incision when necessary.

55 Grinker Roy R, and Guy Chester C. Sprain of Cervical Spine Causing Thrombosis of Anterior Spinal Artery. *J A M A* 85:1140 (April 20) 1927.

56 Codman Ernest A. *Boston M & S J* 196:281 (March 10) 1927.

In all of the cases the indication for operation was based on the general clinical picture rather than reliance on any special signs. The diagnosis of intra-abdominal hemorrhage was correctly made, and the injury of the liver was suspected, as a rule. In one instance the presence of blood in the abdomen was determined before operation by paracentesis.

The object of the operation was to stop the bleeding from the wound in the liver, and this was accomplished by laparotomy and gauze tamponade of the injured area. In the patients who recovered, this measure seemed to answer the purpose sufficiently well.

From the review of these cases, an idea can be formed of the general characteristics of subcutaneous ruptures of the liver. A large proportion of the patients undoubtedly died soon after the accident from shock and intra-abdominal hemorrhage. The lacerations are either marked or else the patient is suffering from acute alcoholism at the moment of trauma and so succumbs readily to shock.

Other ruptures, on the contrary, are slight and may heal completely under merely expectant treatment. However, such ruptures give few signs and probably pass unrecognized during life. For this reason it is hard to compare them with the other more severe forms.

A third type of patient, however, may live for varying periods of several hours to days, and finally may succumb to the continued flow of blood or bile into the abdominal cavity. Some of them might possibly recover if a diagnosis could be made and the appropriate operative procedures instituted, but others probably could not be saved in any event. The mortality is high, even with operation. Finsterer<sup>20</sup> gave the mortality as about 60 or 80 per cent from the estimates of other authors.

In any event, a prompt diagnosis is a matter of great importance and may be difficult in an individual case. External signs of violence are apt to be lacking. The abdominal symptoms are often characteristic, but occasionally may be obscured by other factors, such as acute alcoholism. General rules cannot be formulated, and the recognition of the injury depends on the acumen of the surgeon.

#### SPLEEN

Among the subcutaneous abdominal ruptures, those of the spleen hold the second place numerically. Geill<sup>1</sup> found that they occurred in 33 per cent of all cases of visceral injury. The physical characters of the organ and its protected position in the abdominal cavity explain to a certain extent why it is not as frequently involved as the liver by violence applied to the upper part of the abdomen. The normal spleen

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20 Finsterer H. *Deutsche Ztschr f Chir* 118 1, 1912

months after the onset. The patient was treated with roentgen-ray irradiations and potassium iodide. The case terminated fatally one year later.

That actinomycosis is not as rare as is generally believed is shown by the report of four cases of vertebral actinomycosis by Simpson and McIntosh.<sup>62</sup> These patients were encountered at the Pathological Laboratory of the University of Michigan, two within the past year. All came to autopsy with a clinical diagnosis of tuberculosis of the spine. According to the authors the characteristic lesion in actinomycosis of the spine is cortical erosion of the vertebrae with vertebral phlegmon. Central destruction of the body of the vertebra, with ultimate collapse and deformity such as is found in tuberculosis, does not occur. The roentgenograms should readily distinguish the two conditions. Radical surgical excision of all involved tissue offers the best hope of cure.

*The Snapping Knee*—In an extensive paper describing in all fifty-five cases with twenty-two operations, Kuettner and Liebig<sup>63</sup> discussed the problem of the snapping knee. They distinguished three groups of cases: (1) cases not showing a known injury, in which the cause is either congenital or in connection with subluxation of the tibia forward or with genu recurvatum, (2) cases following distinct trauma, in which the most common cause is displacement or tearing of the lateral semilunar cartilage, less frequently of the medial cartilage or in which rupture of one or both crucial ligaments may be present, (3) cases due to exostoses.

Clinical experience and experiments on the cadaver led Ostrowski<sup>64</sup> to the conclusion that the snapping knee is commonly due to displacement of the lateral meniscus or to the rupture of the anterior crucial ligament or both. The cause is generally of traumatic nature, though the snapping may not begin until some time after the trauma. The only treatment is by operation with excision of the cartilage or repair of the torn crucial ligament.

*Roentgenography of Joints with Iodized Oil*—Sievers<sup>65</sup> employed iodipin for the roentgenologic examination of joints, and his article is illustrated by excellent roentgenograms, especially of the joints of the hips. In congenital dislocation of the hips, many details which remain uncertain in the ordinary films can be shown by this method. The width of the isthmus, the size of the acetabulum and of the capital head and, especially, the results of reduction can be determined accurately.

62 Simpson, Walter M. and McIntosh, C. Alexander. *Actinomycosis of the Vertebrae*, Arch. Surg. **14** 1166 (June) 1927.

63 Kuettner, H. and Liebig, F. *Fragen d. Chir. u. Orth.*, **19** 47 (1922).

64 Ostrowski, S. *Beitr. z. klin. Chir.* **136** 591 (1921).

65 Sievers. *Fortschr. u. d. Geb. d. Röntgenstrahlen*, 1922, 1, 17.

A moderate grade of trauma will produce the bending and the simple ruptures that have been previously described. A marked grade of trauma, however, may crush the spleen into many pieces and at the same time fracture many of the left lower ribs.

The different splenic attachments are supposed to have some influence in the production of many splenic ruptures, especially those which accompany falls from a height. The normal ligaments are peritoneal reflections from the contiguous structures, such as the stomach, transverse colon and diaphragm. Occasional aberrant attachments also occur. At the moment of impact, the spleen has a violent impulse to move, but is checked by the ligaments, so that a parenchymatous tear results near the ligamentary attachments.

The spleen is often lacerated by the broken ends of fractured ribs which penetrate the diaphragm, or it may be torn or in other ways crushed by fractured ribs which do not penetrate. In other instances, a direct localized violence may tear the organ (St John) <sup>22</sup>

Brogsitter <sup>23</sup> described these mechanisms in some detail, emphasizing, however, that in any case it might be difficult to explain the exact way in which the injury was produced.

Spontaneous ruptures of the spleen or ruptures produced by a slight degree of violence are relatively common. In many normal and diseased conditions the organ is large, swollen and engorged with blood, and shows a marked increase in its cellular elements. At such times, the parenchyma is friable and the spleen is especially vulnerable to every slight trauma. Ruptures have occurred during coughing, laughing, sneezing, lifting of weights and similar acts.

The conditions that predispose to spontaneous rupture are predominantly the splenic enlargements in malaria and, to a less extent in typhoid fever, leukemia, typhus fever, cirrhosis of the liver, the last month of pregnancy and similar conditions (Vorwerk) <sup>24</sup>

Anatomically, the ruptures of the spleen are classified as (1) ruptures involving both capsule and parenchyma and (2) ruptures involving the parenchyma alone without a capsular tear. Berger called them *contusions of the spleen*.

Ruptures involving both capsule and parenchyma are the most common. They vary in size from mere jagged splits of the capsule to deep lacerations. Most of them are transverse on the surface of the hilum, though occasionally some are found on the convex surface. A few run longitudinally. Some ruptures are multiple and may be parallel to each other, but more often they take a V, Y, T, H or stellate

22 St John, F B. *Ann Surg* **80** 624 (Oct) 1924

23 Brogsitter, C M. *Charite ann* **33** 494 1909

24 Vorwerk. *Deutsche Ztschr f Chir* **111** 125, 1911

*Statistical Study of Fractures Received During the War*—Continuing his studies of the casualties in battle among the American forces in the World War, Walker<sup>68</sup> stated that there were 147,651 gunshot injuries, of which 25,272, or 17.12 per cent were fractures. Of these men, 2,751, or 11 per cent, died. The total loss of time due to gunshot wounds was 14,544,536 days, and 35.24 per cent of this time, or 5,125,220 days, was due to fractures. The average time lost for each fracture of the femur received during battle, from which the patient recovered, was 326.9 days, for each compound fracture not received in battle, 238.8 days, and for each simple fracture not received in battle 184.4 days. Of the men who had fractures of the femur, only 158, or 3 per cent, were returned to duty. Five per cent were discharged from the hospital in less than 300 days after being injured, 24 per cent in less than 400 days, and 71 per cent required treatment in the hospital for more than 400 days. The number of wounded men discharged from the army on account of disability was 25,187, and of these 11,740, or 47 per cent, were discharged because of fractures. In all there were 32,331 individual fractures received in battle, giving an excess of fractures over patients of 7,059.

[ED COMMENT—With recollections still fresh of the fractures received in the battles in France, of what extensive and horrible injuries they usually represented and of the trying conditions under which the patients had to be treated, we are gratified to learn that the mortality rate did not exceed 11 per cent. We consider this a tribute to the treatment which these patients received.]

*Longitudinal Fracture of the Neck of the Radius*—Phillips and Galland<sup>69</sup> called attention to a hitherto undescribed fracture of the neck of the radius consisting of a longitudinal split extending above the epiphyseal line at the neck of the radius close to its external border distally to the cortex of the bone. They collected reports on 10 cases. The fracture is not ordinarily accompanied by an obvious deformity. The origin of the fracture is difficult to explain on a mechanical basis. It probably results from indirect violence and appears to be caused by a fall with the elbow flexed and the forearm pronated. It is likely an avulsion fracture from the pull on the supinator muscle, a part of which is inserted in the area to which the fracture extends. The treatment is simple support in the forearm cast, and a return to full function usually results.

*Fractures of the Transverse Process of the Cervical Vertebrae*—Of ten patients with fracture of the transverse process of the cervical vertebrae,

<sup>68</sup> Walker, I. S. U. S. War Medical Journal, 1920, 22.

<sup>69</sup> Phillips, Herman B., and Galland, Walter J. J. Bone and Joint Surg., 1938, 20, 1718.

for, and the suggestion that in many instances the injury has stirred up an old septic process or a preexisting malaria is worthy of consideration

Many sequelae to splenic contusions are described. In the older literature, chronic splenic hypertrophy, either of the simple type or of the leukemic variety, is mentioned as a result of a contusion, but in recent years the tendency has been to doubt this conclusion.

The more usual results are local changes in the splenic parenchyma. Small injuries usually heal by absorption of the blood and the formation of an internal scirrhous scar. Larger effusions develop into true traumatic cysts filled with transformed brownish blood. In rare instances they can become infected by bacteria transported through the arterial blood, and encapsulated abscesses result. If the parenchyma is much damaged, large traumatic infarcts occur, which can serve as a nidus for future infection and may lead to a fatal termination.

A glance at the ruptures of the spleen, as they occurred in the material obtained at necropsy, brought out the fact that the majority were combined with other internal injuries. It was difficult, in a study of these cases, to reach any satisfactory conclusion concerning the effect of the splenic lesion on the system. Only a few isolated ruptures were discovered, and most of them were included among the clinical cases in which operation had been performed. Only three patients had died without operation, and these cases merely served to point out the fact that death was likely to occur after a lapse of several hours from an intra-abdominal hemorrhage. Trauma to this organ rarely produced such rapidly fatal results as were characteristic of some hepatic injuries.

The clinical cases follow.

#### CLINICAL HISTORIES

CASE 1—A boy, aged 16, while coasting, struck his left side against a tree. He was not unconscious after the injury and was able to walk, though he felt a trifle dizzy. On admission to the hospital, he complained of pain in the left part of the abdomen, thirst and shortness of breath, he appeared pale. A laparotomy was performed a few hours later. The spleen was found lacerated completely across and was removed. The patient died twenty-one hours after the accident from weakness and loss of blood.

CASE 2—A man, aged 21, fell 50 feet. He was not unconscious after the injury. On admission to the hospital, a contusion was present over the region of the left flank. He was pale, the abdomen was rigid, especially in the left upper portion, and blood was found in the urine. The left femur also was fractured. An operation was performed and the spleen was found to be ruptured near its lower pole, it was removed. The abdominal hemorrhage was removed. A rupture of the left kidney was found, and the kidney was removed. The wounds later became infected, and death occurred five days after the accident, from streptococcic septicemia.

CASE 3—A man, aged 26, was crushed in an elevator. He was admitted to the hospital in a state of shock with cramplike pains in the abdomen. The

[ED COMMENT—Wolcott's results are in agreement with the experimental observations of Key to which attention has been called in a previous "Report of Progress in Orthopedic Surgery"]

Seeliger<sup>73</sup> performed experiments on rabbits to determine the rate of blood in the joints. He was unable to show the presence of any special ferment that would prevent clotting of blood inside the articulation. He concluded that whether or not clotting takes place after injury with intra-articular bleeding depends entirely on the function which the joint is permitted. If the joint is placed at rest, clotting occurs. Later the cellular elements are eliminated and the serum absorbed. If, on the other hand, motion is permitted, clotting does not occur and the action is similar to defibrination of blood outside the body which is produced by stirring or beating it in a glass container.

*Experimental Radium Arthritis and Articular Neoplasm*—Experimenting on rabbits by the introduction of radium into the joints, Fisher<sup>74</sup> produced changes that were characteristic of arthritis. In one rabbit an intra-articular periosteal sarcoma developed.

*Roentgenologic Examination of the Shoulder*—King and Holmes<sup>75</sup> studied 450 roentgenograms of the shoulder in an effort to find an answer to the question of why the roentgen-ray examination gives negative results in such a large number of shoulder cases. Of the films examined 66.6 per cent were interpreted as giving negative results. The authors concluded that this high percentage of negative results may be materially reduced by a more careful physical examination to exclude cases in which the pain is referred to the shoulder from lesions in other situations. Further, they advised making one underexposed film as well as a normal one with the shoulder externally rotated in order to demonstrate insertion fractures of the supraspinatus and subacromial bursitis.

*Influence of Surrounding Tissue on the Fate of Transplanted Bone*—Wereschtschinski<sup>76</sup> performed a series of experiments on animals to determine the influence of surrounding tissues on transplanted bone. For transplantation he employed autoplasmic bone pegs and attempted to have them fresh, living and covered with periosteum. The surrounding tissues were changed as little as possible. Cultures of bone tissue in a test tube did not show new growth of bone. Implantation of bone in the soft tissues was followed by only slight formation of bone.

73 Seeliger, P. *Klin. Wchnschr.* 5:1616, 1926.

74 Fisher, A. G. T. *Brit. M. J.* 1:319 (Feb. 19) 1927.

75 King, I. M., Jr. and Holmes, G. W. *Ann. J. R. A. S.* 17:114, 1927.

76 Wereschtschinski, A. O. *Wchnschr.* 1927, 1928, 1929.



after admission. A deep laceration was present across the lower pole of the spleen. Blood was present in the abdomen. He recovered in eighteen days.

CASE 11—A man, aged 39, fell 20 feet from a scaffold, landing on his left side. He was pale, showed a rigid and tender abdomen and complained of pain in the left side, especially on respiration. Splenectomy was performed about twenty-four hours after the trauma. Considerable blood was present in the abdominal cavity. He recovered in thirty-two days, the only sequela being a slight hernia in the scar.

CASE 12—A man, aged 42, was run over by an automobile. He was admitted to the hospital in a state of shock, with severe abdominal pain, especially in the left lumbar region. Luxation was present at the outer end of the right clavicle. Splenectomy was performed the same day, and the blood in the abdominal cavity was removed. A transverse laceration of the spleen was present. The luxation of the right clavicle was reduced. The patient recovered in thirty days, but developed an abscess in the abdominal scar that healed and left a small hernial protrusion.

Of the twelve patients described, four died and eight recovered, which seems to indicate that the mortality is considerably less in ruptures of the spleen than in ruptures of the liver, especially if the patient survives long enough to receive surgical treatment.

These cases illustrated most of the important clinical signs associated with the injury. Shock was sometimes present, but was never overwhelming, four patients were described as being able to walk after the accident. The signs of internal hemorrhage were present, the patients showing pale skin, rapid pulse, dyspnea and thirst. Abdominal pain, rigidity and tenderness were present and often were especially marked near the left hypochondrium. In a few instances, the pain was aggravated by respiration. In three cases, the intraperitoneal hemorrhage gave the sign of shifting dullness in the flanks.

In three cases (4, 5 and 6), the symptoms apparently were not alarming immediately after the accident, and the patients did not enter the hospital until a few hours had elapsed.

The injuries described were of varying grades of severity, from superficial lacerations to fragmentation of the splenic pulp. Splenectomies were performed on eleven patients, four of whom died. One case showed slight laceration of the spleen, which was not bleeding at the time of operation, and so the spleen was not removed, the patient recovered without incident. This case perhaps suggests an explanation for some of the good results that have attended such operative procedures of the past as tamponade of the rupture and suture of the lesion in situ. It merely indicates that a few splenic injuries are not necessarily fatal and would probably recover spontaneously. However, the treatment of choice is splenectomy, as it gives the only adequate assurance that the laceration itself will no longer bleed. Tamponade or suture of a severe injury in such a vascular organ as the

## SUBCUTANEOUS INJURIES OF THE ABDOMINAL VISCERA

CAUSATION AND CLINICAL CHARACTERISTICS\*

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Two types of lesions are produced by physical violence on the abdominal cavity and its organs. The first is represented by stab wounds and lacerations, which penetrate the skin and leave characteristic external marks. They are known as percutaneous injuries. The second type is due to the action of nonpenetrating blunt force which is directed to the abdominal viscera but which may or may not cause a lesion of the surface of the skin. These are called subcutaneous injuries. Of the two, the second variety offers more difficult problems of diagnosis and treatment than the first. While the percutaneous variety can readily be overlooked because of the penetration of the skin, the subcutaneous injury often lacks external indications and is often easily overlooked on examination. As many of these injuries are serious, though not necessarily hopeless if the patient is given prompt treatment, their early detection is a matter of grave importance to the surgeon.

The subcutaneous abdominal injuries and the symptoms that they produce are so varied that it would be impossible to give any set of rules specific enough to serve as a guide for early diagnosis. However, a brief systematic presentation of the different lesions, indicating what can be logically expected from the action of blunt force on the abdomen, might be of value, and such a review is attempted here.

As the type of the abdominal injury depends to a great extent on the nature of the violence, a classification of the different forms of blunt force is necessary. There are two main categories:

(a) Generalized violence, or trauma that involves the abdomen as a whole. Examples of this comprise accidents in which the patient is run over by a vehicle, falls from a height, is compressed between two colliding objects or is crushed by a falling mass.

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Structurally, they are vascular parenchymatous masses which, under normal conditions, have a consistency about that of the normal liver. They have the customary reniform shape, with an average weight of about 150 Gm. Each is closely invested by a firm fibrous capsule which is, in turn, surrounded by adipose tissue in greater or less quantity. In the adult, this investment is usually generous, while in the child it is scanty. As the perirenal fat protects the organ from violence to a certain extent, its amount has an important bearing on the complications of the rupture.

The kidneys are ruptured either by a severe trauma or by a relatively slight one. From their anatomic position, it is probable that the less intense grades of violence rupture the organ when applied to the lumbar regions, while only the very marked grades produce their effects by acting on the anterior abdominal wall.

According to Kuester (cited by Boettiger),<sup>25</sup> the basic factor in the production of the lesion is a bursting of the parenchyma due to a sort of hydraulic mechanism. In his experiments on the cadaver, he noticed that kidneys engorged with blood were more easily and more deeply wounded than those comparatively bloodless. It is probable that in many instances a moderate grade of violence will produce a marked lesion if the organ is markedly congested. When the parenchyma is rendered especially friable, because of a pathologic condition like renal tuberculosis or a suppurative inflammation, the rupture may occur under such a slight trauma that it can be classified as spontaneous.<sup>25</sup>

The majority of ruptures are transverse and are directed more or less at right angles to the longitudinal axis. They are probably the result of a force that bends the organ so that the anterior or posterior surface is rendered sharply convex. Several explanations have been advanced to account for this mechanism.

A localized violence, like a blow or kick over the twelfth rib, will drive the rib against the middle of the kidney and either tear the parenchyma directly on the posterior surface or cause the anterior surface to bulge sharply forward and rupture. However, any force that adducts this rib will produce a similar effect, even a sudden movement of the muscles of the trunk.

Some lacerations are said to be the result of a contrecoup violence. A severe force applied to the flank is supposed to crush the kidney against the lumbar vertebrae and extensively lacerate the parenchyma. In any case, it would be difficult to determine just what mechanisms were operative at the time of the trauma, and the question is of theoretical rather than of practical interest.

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<sup>25</sup> Cited by Boettiger, K. *Deutsche Ztschr. f. d. ges. gerichtl. Med.* 8:33, 1926.

is occur in accidents in which the patient is run over by a vehicle, falls from a height, is crushed between the bumpers of freight cars or receives thrusts with a wagon pole and kicks (Lidder<sup>2</sup>).

The normal organ will be broken only under the application of a marked degree of violence, but in some instances a pathologic condition is present which increases the fragility of the parenchyma. Ruptures may then occur under the influence of such slight trauma as a sudden movement of the trunk; hence they must be classified as spontaneous. Westenhoffer<sup>3</sup> described such a rupture in a liver that was secondarily involved by carcinoma, and Witzold<sup>4</sup> mentioned a parenchymatous tear caused by the bursting of an intralobar aneurysm. However, these cases are rare.

There is little agreement in the literature concerning the way in which ruptures of the liver are produced. As Walz and Holle<sup>5</sup> have pointed out, the same variety of trauma may produce different injuries in different cases and conversely similar lesions may result from dissimilar forms of violence. The exact course of events which takes place at the moment of the casualty must be a matter of conjecture in many instances, and even necropsy may fail to disclose the true modus operandi or the mechanism. This question can be considered more advantageously in connection with the different types of injury.

Hitzrot's<sup>6</sup> classification is perhaps the most suitable. He divides the subcutaneous injuries of the liver into (1) true ruptures, in which both capsule and parenchyma are torn, (2) subcapsular ruptures in which the lesion is produced below the intact capsule.

The true ruptures of the liver vary widely in size, shape, position and mode of production. The most common varieties are the cracks in the sagittal plane found on the upper convex surface. They occur as shallow fissures more or less parallel or as larger single lacerations which divide the parenchyma partially or completely. Some are undoubtedly produced by an extreme bending of the organ in such a way that the diaphragmatic surface is rendered acutely convex and the right and left poles are forced downward toward each other. The result is a break of the liver at right angles to the axis of bending, and consequently the direction of the rupture is in the sagittal plane of the body. Lateral compression of the trunk at the level of the lower ribs causes many lesions of this sort.

According to Walz and Holle,<sup>5</sup> sagittal ruptures on the upper surface follow falls from a height if the body lands on the head or shoulders. If the lungs are in full expiration at the moment of impact

2 Lidder, L. *Arch f klin Chir* **34** 343, 1887.

3 Westenhoffer. *Munchen med Wehnschr* **51** 41 (Jan 5) 1904.

4 Witzold. *Munchen med Wehnschr* **53** 2107 (Oct 23) 1906.

5 Walz and Holle. *Vrtljschr f gerichtl Med* **40** 215, 1910.

6 Hitzrot, J. M. *Ann Surg* **66** 50 (July) 1917.

group 3, but in a few instances prompt formation of thrombi in the torn vessels may stop the bleeding. The fragmented parenchyma, however, becomes speedily necrotic and, if treatment is not instituted, develops into a septic phlegmon or an abscess.

5 Severe renal trauma often is accompanied by the partial or complete tearing of the blood vessels and the ureter. Severe perirenal hemorrhage, extravasation of urine and necrosis of the kidney occur in varying degrees. A massive swelling may develop in the lumbar region from the perirenal accumulation. The fluid causes an inflammatory reaction and may form a cystlike structure around the kidney, which is called a pseudohydronephrosis by some. This complication develops within a week after the trauma, as a rule.

In a few instances a true hydronephrosis, that is, distension of the renal pelvis and parenchyma by urine, may follow the trauma. The usual causes are a fibrous stricture of the ureter following a direct injury of that duct, an extensive perirenal hematoma which compresses the ureter directly, or some obstruction inside the duct itself, such as a blood clot or a preexisting calculus. Boettiger<sup>25</sup> believed that the blood clots are not potent causes of hydronephrosis, as they tend to disintegrate in a week or so and pass into the bladder. Some hydronephroses are described as having been caused by a traumatic displacement of the kidney from its bed, which results in subsequent kinking and blocking of the ureter. The true hydronephrosis takes weeks or months to form and can thus be distinguished from the pseudohydronephrosis which develops more rapidly.

In rare instances, injuries around the hilum cause traumatic aneurysms of the renal artery. They may reach the size of a child's head and form a large tumor in the flank, which may pulsate and give a systolic murmur. They occur in two forms, one of which originates in the extrarenal portion of the artery, while the other may develop inside the substance of the kidney. Both types cause a more or less pressure atrophy of the kidney.

Only a small proportion of renal injuries result in a severe intra-abdominal hemorrhage—only 57 per cent, according to Kuester.<sup>27</sup> These hemorrhages usually occur in children at the age when the perirenal fatty capsule is poorly developed and the kidney is somewhat nearer the anterior abdominal wall than it is later in life. The violence is necessarily severe and tears the peritoneal layer over the kidney as well as the kidney itself. Death usually results from the intra-abdominal hemorrhage, but in a few instances, when the renal pelvis is torn, urine will be extravasated with the blood and will cause a

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27 Cited by DeQuervain, F. *Deutsche Ztschr. f. Chir.* 62:59, 1902.



abdomen The urine was bloody Operation was performed on the day of admission by a laparotomy incision Blood was not found in the abdomen A big perirenal hematoma was present on the right side The right kidney was ruptured across its midportion A nephrectomy was performed through the laparotomy opening The patient recovered in sixteen days

CASE 6—A boy, aged 16, while running, fell with his left side against an iron bar On admission to the hospital two hours later, he complained of pain in the left side The upper left abdominal quadrant was rigid A few contusions were present over the eleventh and twelfth ribs on the left side The urine was bloody A nephrectomy was performed by lumbar incision The left kidney was surrounded by a perirenal extravasation of bloody urine The upper pole of the kidney was nearly severed, the laceration extending to the pelvis Recovery occurred in sixteen days without important sequelae

The six clinical cases, in all of which recovery occurred, showed several points of interest

The symptoms were fairly consistent, pain and tenderness were present in the right or left flanks, as the case might be, and blood was found in the urine in variable quantities In cases 1 and 2, the diagnosis was made on these points alone and, as the symptoms were not particularly alarming, an operation was not performed Of course, under these circumstances, the diagnosis of renal injury was scarcely conclusive, as pain in the flanks may result from many causes, and even blood in the urine may be due to many other conditions The cases are described, however, in order to show that mild forms of injuries to the kidneys are fairly prevalent, and to suggest that not a few of these patients recover under expectant treatment

These patients who were operated on showed much more severe injuries One recovered after the moderately severe lacerations of the parenchyma had been sutured The injuries evidently were not incompatible with renal function The other three patients had a badly shattered kidney and the only course to pursue was to remove it, as a fatal abscess would have resulted if the kidney had been allowed to remain in the body

None of the patients developed sequelae of any importance, nor did the function of the kidneys appear to be damaged in any way The different types of posttraumatic nephritis and other renal disturbances mentioned by Wagner<sup>26</sup> fortunately were all absent

In general, the prognosis appears to be favorable The figures of other authors, cited by Wagner,<sup>26</sup> place the mortality in general at 18.6 per cent for all forms of treatment The patients treated expectantly showed a mortality of 20 per cent, in those treated by conservative surgical means, which is any procedure short of nephrectomy, the mortality was 14.6 per cent, while in the cases in which nephrectomy was performed, the mortality was 16.7 per cent There is no doubt that some of the ruptures of the kidneys that evoke symp-





occur at the left extremity of the gland near the tail, though a few occur at the middle of the organ or at the right extremity where the head joins the body. It is reasonable to assume that the violence would crush different portions of the pancreas, depending on whether the resistance was furnished by the central portion of the vertebral projection or the sides (fig 4).

The usual result of the complete rupture is death by shock and abdominal hemorrhage. Some patients, however, have been operated on and have recovered. Karewski's<sup>29</sup> patient had a complete rupture through the middle of the gland, but was successfully treated by a

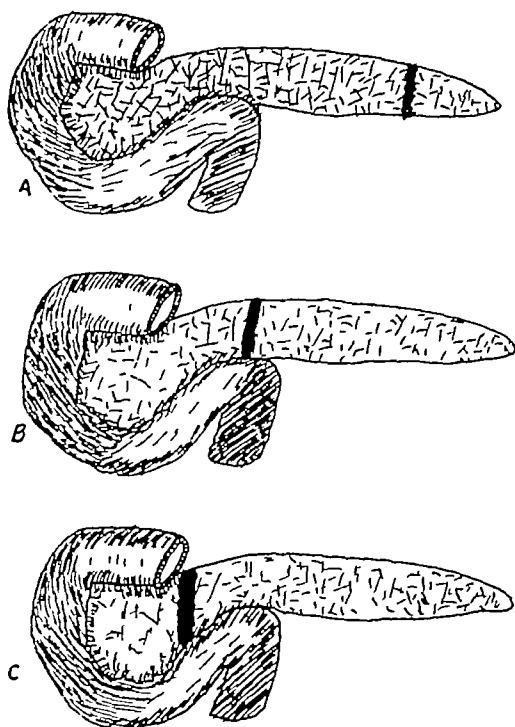


Fig 4—Ruptures of the pancreas

tamponade of the injured area with a drain. Thole<sup>30</sup> described a similar case. Wildegans<sup>31</sup> successfully sutured a complete separation of the head of the pancreas from its body, and obtained healing without after-complications. If the edges of the rupture are not necrotic, the suture of the capsule apparently is sufficient, but otherwise tamponade and drainage are necessary. The results of operation, however, are not encouraging, as the mortality is high—according to Karewski, about 72 per cent. A troublesome pancreatic fistula in the scar caused by the laparotomy frequently complicates these operations. In other instances, the lacera-

29 Karewski, F. *Berl klin Wchnschr* **44** 187 (Feb 18) 1907

30 Thole. *Deutsche Ztschr f Chir* **84** 45, 1906

31 Wildegans. *Arch f klin Chir* **122** 276, 1922-1923

compressible chest wall (Stierlin)<sup>18</sup> Associated ruptures of the parenchyma of the liver are not present, as a rule

Ruptures of the large intrahepatic bile ducts are also found and are necessarily associated with a break in the substance of the liver. Any wide and deep laceration of the parenchyma will tear some of the larger branches, but the more characteristic lesions are seen in connection with small sagittal ruptures on the under surface of the organ. They begin at the anterior edge of the liver in the furrow in which the round ligament lies and run backward into the hilum, tearing the left hepatic duct across. This force probably elevates the left lobe of the liver toward the right, so that the bile duct is put under stress.

If death does not occur within a short time from shock and intra-abdominal hemorrhage in cases of rupture of the biliary tract, the continued excretion of bile finally dominates the clinical picture. The bile may be extravasated into the retroperitoneal tissues, in rare instances, if it cannot gain access to the peritoneal cavity either because the peritoneal layer is unbroken or because the rupture is surrounded by adhesions. Collections of bile have been seen around the region of the liver behind the ascending and descending colon, and even extending into the chest behind the diaphragm and pleura.

The usual course, however, is for the ruptured duct to secrete the bile in the abdominal cavity in quantities varying with its caliber. The smaller ducts produce only a small amount and later are closed by plugs of fibrin and scar tissue, this closure is analogous to that of the smaller blood vessels. The larger ducts, however, pour out bile continuously and are rarely closed by a spontaneous process. The bile in the abdominal cavity gives rise to a chain of symptoms that develop slowly and are characteristic.

This complication can best be illustrated by a case that came to necropsy. A young man, aged 20, fell into an excavation with his automobile. At first he complained only of pain in the right hypochondrium. At the end of four days, he developed a pronounced jaundice, and bile appeared in the urine. Eight days after the injury the bile pigment disappeared from the skin and urine, but at the same time he developed a steadily increasing ascites which caused pressure symptoms. Abdominal paracentesis showed this to be pure bile. A laparotomy was not performed. He died on the fifteenth day following the trauma.

At necropsy, the body was poorly nourished and pale, but not jaundiced. The abdominal cavity was distended with about 8 liters of yellowish-brown, bile-stained fluid. The entire peritoneum including the diaphragm was covered by an adherent, fibrinous, bile-stained membrane, about 5 mm thick, which caused marked contraction of all the hollow viscera and numerous sticky adhesions between adjacent structures. The large intestine contained a few pasty, clay-colored stools. The viscera and the body fluids outside the peritoneal cavity were not jaundiced.

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18 Stierlin, R. *Deutsche Ztschr. f. Chir.* 73: 463, 1904.

cedure is dangerous and difficult. A pancreatic fistula is prone to develop in the operative scar and may be slow to close.

The endopancreatic cysts are of two kinds. (a) One type is analogous to the peripancreatic variety and cannot be distinguished from it when the process is fully developed. The only difference is in the initial hematoma, which is supposed to be located more in the substance of the gland and less in the retroperitoneal layer. The development is so similar that it need not be repeated. (b) A second type is considered to be due to a lesion in the head of the pancreas, which finally results in the formation of scar tissue around the larger secretory ducts. An obstruction to the outflow of secretion occurs, and dilatation of the ducts consequently results. Some of the finer branches rupture, and an effusion of secretion takes place in numerous places in the gland. A reactive inflammation is set up and numerous small cysts, about 1 cm in diameter, occur in the pancreatic substance. The process of development is slow. The traumatic etiology in this process has been vigorously disputed, as it has been described in cases in which a history of pancreatic injury was not present. Honigsmann<sup>33</sup> and Mueller<sup>34</sup> described pancreatic cysts.

In the material obtained at necropsy rupture of the pancreas occurred only four times, or 4.4 per cent, in a total of eighty-nine cases of abdominal trauma. As all of these four cases were associated with severe lesions of the other viscera, not much information was to be gained from them. The clinical records did not yield any examples of pancreatic injury, thus indicating its comparative rarity.

#### SUMMARY

The parenchymatous organs of the abdominal cavity comprise the liver, spleen, kidneys and pancreas. They are located in the epigastrium and are well protected from external violence, so that as a rule a marked degree of force is required to rupture them. The different organs may be injured either alone or in combination with other traumatic lesions.

The first complication that follows the accident is shock. Later on, intraperitoneal hemorrhage results from the blood vessels in the affected organ that have been torn by the rupture. In most instances, death is the result of the hemorrhage.

The other complications depend on the individual organ that has been injured. Ruptures of the liver occasionally give rise to an effusion of bile into the peritoneal cavity because of an injury to the biliary tract. Ruptures of the kidney cause trouble because of urinary

33 Honigsmann, F. *Deutsche Ztschr f Chir* 80 19, 1905

34 Mueller, H. *Arch f klin Chir* 143 285, 1926

died of intra-abdominal hemorrhage. In one a laparotomy was performed and the laceration was packed with gauze, but this did not halt the hemorrhage.

4 Two patients lived from four to five days after the injury. One had a craterous laceration of the right lobe and died of a combined hemorrhage and effusion of bile into the abdominal cavity. A large traumatic infarct was present about the laceration (fig 1). The other patient sustained a few superficial lacerations of the right lobe, but bled only a little intra-abdominally. The cause of death was terminal pneumoma, to which a state of chronic alcoholism contributed as much as the rupture of the liver.

TABLE 1—*Causes of Casualties*

Accidents in which the patient was run over by a vehicle	13
Falls from a height	5
Crushed between a barge and the pier	1
Struck by falling steam shovel	1
A foot stamp on the upper part of the abdomen	1

TABLE 2—*Age Incidence*

1 to 10 years	6
20 to 30 years	6
31 to 40 years	3
41 to 50 years	2
51 to 60 years	3
61 to 70 years	1

5 Two patients lived eleven days and fifteen days, respectively, after the injury. Both showed superficial sagittal lacerations of the under surface, which involved the main branch of the left intrahepatic bile duct. Death was due to a continuous effusion of bile into the abdomen, in the manner that has already been described. Abdominal section and packing of the lacerated area was tried in one of these patients, but apparently the operation was performed too late to be of benefit.

Adequate conclusions concerning the mortality of ruptures of the liver in general cannot be drawn from these cases. However, it is obvious that a large proportion (33.3 per cent) of the patients died immediately after the accident, and 38.1 per cent died during the first six hours of their admission to the hospital. They were in such a state of collapse that operative measures could not be attempted. Only 28.6 per cent lived a sufficient length of time for an adequate clinical observation to be made, and in only two of these was a laparotomy

state it is well protected by the pelvis, and it is vulnerable only when it is in a state of full distention. The parenchymatous organs, on the other hand, are less free to move and cannot easily avoid the violence, even though they are better protected by their position and structure, they sustain far more injuries than the hollow abdominal organs.

#### THE GASTRO-INTESTINAL TRACT AND ITS MESENTERIES

Subcutaneous injuries of the gastro-intestinal tract and its membranes are relatively infrequent. Geill<sup>1</sup> mentioned that the intestine is ruptured in 11.1 per cent and the stomach in 7.1 per cent of his collection of cases.

There are three ways in which these organs can be affected by violence. The first method is by crushing or contusion. The force directly compresses some portion of the gastro-intestinal tube or its mesentery between the anterior abdominal wall and a hard layer of bone, like the spine or pelvis, on the posterior wall. A severe bruising of the affected portion and possibly a definite perforation of the wall may occur. At the moment of injury, the stomach or intestine contains little content, as a rule. The second method is by tearing. The force in this case is violent and compresses the anterior wall and then moves over the abdomen in a tangential fashion. Traction is put on the gastro-intestinal canal or its mesentery, and one or the other is torn in various ways. The third method is by bursting or explosion. This mechanism operates only on the stomach, duodenum or intestines and cannot act on the mesentery. It is produced by any violence which causes a sudden rise of pressure in the lumen of the tube, and the rupture results when the hydraulic force within is sufficient to overcome the resistance of the wall of the viscus. The favorable condition for the rupture is the presence of a large fluid content which distends the canal.

The most convenient way to study the gastro-intestinal injuries is to divide the tract into its natural subdivisions of stomach, duodenum and intestines. The lesions and their complications are characteristic enough for each segment to merit separate consideration.

*Stomach*—Ruptures of the stomach are relatively rare. Of ninety cases of abdominal injuries, five lesions of the stomach were found. The organ lies in the epigastrium and is protected to a certain extent by its deep position and by the arch of the lower part of the chest. The violence required to damage this viscus is considerable, both because of its location and because its walls are tough and muscular. The usual trauma is severe and generalized, and other viscera usually suffer at the same time.

A contusion was described in one instance. The abdomen had been trodden on during a homicidal assault. The stomach showed symmetrical stellate ruptures of the mucous membrane on the anterior and

sisted for a few weeks, but finally healed. One year after the injury, a second laparotomy was performed to loosen fibrous adhesions around the site of the injury. The scar was firm. With the exception of a neurotic condition, the result was good.

CASE 7 (Auchincloss)<sup>6</sup>—A girl, aged 12, was coasting on a sled and collided with a tree. After the injury, she was not unconscious and walked one-half mile to her residence. She was admitted to the hospital six hours later, complaining of pain and tenderness in the upper part of the abdomen and pain in the right shoulder. The skin over the upper right abdominal quadrant was reddened. Fifteen hours after the trauma, an operation was performed, and a horizontal tear of the upper surface of the right lobe was found. About 400 cc of blood was found in the abdomen. The laceration was packed with gauze. The patient recovered in thirty-one days and, aside from slight bulging of the scar, was in a good condition.

CASE 8—A man, aged 48, who was struck by an automobile, was unconscious after the injury, but walked to the ambulance. On admission to the hospital he showed abdominal pain and rigidity and pain in the right shoulder. A preliminary abdominal tap showed the presence of blood in the cavity. A laparotomy was performed twelve hours after the trauma. A vertical linear tear of the right lobe of the liver was found, which was packed with gauze. The blood was evacuated, and the patient recovered twenty-two days after the accident.

CASE 9—A girl, aged 9 years, fell 12 feet onto a stone floor. She entered the hospital in shock and was pale and restless, showing a rapid pulse and complaining of pain in the abdomen, especially on respiration. Tenderness and rigidity of the right upper abdominal quadrant were present. A few hours later, a laparotomy was performed. Blood was present in the abdomen and a rupture of the right lobe was found, which was packed with gauze. She recovered about twenty days after the trauma.

These cases illustrate several of the different clinical signs and symptoms that characterize injuries of the liver. Different degrees of shock were noted. In a few instances the patient was knocked unconscious and was in severe collapse. In others the immediate effects of the injury were not alarming, four of the patients being able to walk a greater or less distance.

Signs of abdominal hemorrhage were frequently present, as indicated by pallor, restlessness, cold skin and dyspnea.

Rigidity and pain in the abdomen, especially in the region of the liver, were noted in all of the cases except those in which marked shock was present. Pain referred to the right shoulder was present in three cases. This symptom has often been emphasized in the literature as typical of an injury to the liver.

External indications of injury to the region of the liver were evident in four instances. Two patients had fractures of the ribs on the right side near the right hypochondrium. One had an abrasion of the lower right quadrant of the chest anteriorly, a fourth showed an erythematous area at this point.

exposed position, the pylorus is much more vulnerable to the tearing mechanism than the more deeply placed cardia

A bursting or explosive rupture of the stomach was encountered twice. The organ was distended with food content at the moment of the casualty and, when pressed on, ruptured at the fundus. The lesion appeared as a small circular perforation, from 1 to 2 cm in diameter, situated on the most dependent portion of the greater curvature, somewhat to the left of the median line of the abdomen (fig 5 A). The stomach was contracted, and the abdomen was full of acid food content and brownish blood.

In these cases, death was due to shock and hemorrhage from injuries of other viscera, though in two cases the acid gastric content had set up a marked chemical peritonitis, which contributed to the death of the patient.

*Duodenum*—The duodenum is more deeply placed, but is occasionally ruptured because of the greater fragility of its walls. It is a U shaped tube situated in the epigastrium around the head of the pancreas. Its more distal portion passes over the bodies of the lumbar spine, and it is at this point that a severe localized violence can impinge on its wall. A case is described in which the duodenum was crushed between the anterior abdominal wall and the vertebral bodies and sustained a complete perforation of the anterior wall and a partial perforation of the posterior wall, at the same level (Vance)<sup>36</sup>. Tears also occur at this point and are caused by a tangential force which puts a transverse traction on the most dependent portion of the tube, severing it either partially or completely. Bursting ruptures are found and are the probable result of a force applied directly to the duodenum when it is in a state of distention. The lesion appears as a circular opening in the most dependent portion of the U shaped canal.

The result of the perforation is to allow the contents to escape into the retroperitoneal tissues, with the consequent production of a gaseous gangrenous cellulitis which proves speedily fatal. This complication may give definite clinical signs which may lead to an exploratory laparotomy. Unfortunately, because of its retroperitoneal location, the lesion is frequently overlooked at operation (Berry)<sup>37</sup>.

*Intestines*—The intestines are injured more frequently than the stomach or duodenum, principally because they are placed in an exposed position in the abdominal cavity. The small intestine is arranged in coils and fills a space from a level just above the umbilicus down to

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36 Vance, B. M. Traumatic Lesions of Intestine Caused by Nonpenetrating Blunt Force, *Arch Surg* 7 197 (July) 1923

37 Berry. *Brit M J* 2 643 (Oct 22) 1921

is a small vascular organ, varying in weight from 50 to 350 Gm. It is covered by the left vault of the diaphragm and guarded by the tenth and eleventh ribs on the left side. Its long axis is parallel to the curve of these ribs and its upper pole is situated about 2 or 3 cm. distant from the body of the eleventh dorsal vertebra. Although it is attached by its ligaments to the surrounding structures, it enjoys a certain degree of mobility. All of these conditions work in such a manner that the spleen escapes the results of the violence in many instances.

The normal spleen, as a rule, is reached only by a relatively severe trauma. The mechanism of the rupture has been explained in various ways. Some believe that, with a sudden localized force, such as a blow or a kick acting on the left hypochondrium, the spleen bursts by hydraulic action, especially when its blood vessels are engorged and its pulp is friable. With the sudden increase of internal pressure imparted by the impact, the capsule, which is already tense, will be overstretched and will rupture at its weakest point. Berger<sup>21</sup> declared that this injury is exactly analogous to ruptures of a hollow viscus, such as a urinary bladder fully distended by urine.

Other forms of violence cause the spleen either to bend in the direction of its longitudinal axis, in which case the rupture will be across the organ, or to bend in the transverse axis so that longitudinal ruptures will be produced. The ruptures invariably occur at right angles to the axis of bending on the surface which is rendered convex.

The most common lesions are transverse ruptures of the surface of the hilum, which means that the spleen is overextended or so bent that the surface of the hilum is rendered acutely convex in the longitudinal axis. Several ways have been described in which this result can be attained. In young persons with easily compressible chest walls, a sudden force applied to the left side will drive the ribs against the convex surface of the spleen and cause the surface of the hilum to bow to the right. The action seems to be comparable to the sudden protrusion of the abdomen which follows a violent shove in the small of the back. In other instances a severe tangential force, which travels across the epigastrium from right to left, may drag the lower pole of the spleen below and beyond the lower margin of the left ribs, thus producing the overextension.

Transverse ruptures of the convex surface are caused by overflexion of the spleen. This is supposed to occur as a result of a severe violence which compresses the left side of the chest and catches the two poles of the spleen between the ribs and the body of the eleventh dorsal vertebra.



marked ecchymosis around the lesion. The bruising may injure the wall to such an extent that a secondary perforation may occur a few days after the injury and cause a fatal peritonitis. In a few instances, the injury can cause a necrosis of the wall and so damage the vitality of the tissues that bacteria will enter the peritoneum without actual perforation.

Contusions of the mesentery occur, but as they are rarely associated with intestinal injuries, they will be discussed later.



Fig. 6—Partial tear of small intestine with injury to an *Ascaris* worm in that segment.

Injuries resulting from bursting occur, and their appearance is characteristic. They are found as small circular or ovoid perforations on the wall, generally opposite the mesenteric attachment but occasionally near it. Most of them are single, but in a few instances they may be multiple. They are due to some force that causes a rise of pressure inside the cavity of the intestine, which at the time of injury is distended by fluid. Different explanations have been advanced to account for this mechanism.

form When the force has been particularly intense, the spleen is often found fragmented and its ligaments torn in varying degrees (fig 2)

The immediate complication following the rupture is hemorrhage into the abdominal cavity This may be slight or sufficient to cause death If the bleeding is slow, a blood clot may be attached to the rupture and may surround the organ During the first few hours the blood retains its normal color, but later undergoes the same changes that were described before If infecting bacteria gain entrance in any way, a septic peritonitis will result In some instances in which the spleen becomes adherent to the surrounding structures, a subphrenic abscess may develop

The small splenic ruptures tend to undergo healing with the formation of scars Occasionally, anemic traumatic infarcts are encountered



Fig 2—Y-shaped rupture on convex surface of spleen

around the edges of larger lacerations, analogous to the lesions of the liver that have been described

The contusion of the spleen is the result of a violence that ruptures the parenchyma without breaking the capsule, so that a hematoma is formed in the substance The effusion of blood may be sufficient to cause an appreciable enlargement of the organ Blood may be extravasated into the perisplenic tissues Occasionally, inflammatory changes take place in the capsule and the spleen may become adherent to the surrounding viscera

The symptoms of the contusion are described as (1) severe pain in the left hypochondrium, (2) splenic enlargement and (3) a daily fever of the quotidian type

The pain and tumor are easily explainable on the basis of the anatomic changes The pyrexia, however, is not so easily accounted

## CLINICAL HISTORIES

## FATAL CASES

CASE 1—A man, aged 65, fell downstairs, landing on his abdomen. He was admitted to the hospital twenty-two hours later in a state of shock, complaining of pain, distention of the abdomen and vomiting. He had bilateral inguinal hernial sacs, the one on the left being the larger. A laparotomy was performed shortly after admission. A perforation of the ileum, 1 cm in diameter, was present, about 3 feet (91 cm) proximal to the ileocecal valve. This was closed by suture. Death occurred about a day and a half after the injury.

CASE 2—A boy, aged 13, fell from a chair, landing on his abdomen. He complained of severe abdominal pain, vomiting of feculent material and diarrhea. He was admitted to the hospital thirty hours after the injury in a marked state of shock, with abdominal pain and distention. The leukocyte count was 44,000, and the polymorphonuclears numbered 94 per cent. A laparotomy was performed shortly after admission. A perforation 1 cm in diameter was found near the mesenteric insertion of the jejunum, in the upper portion. A fully developed peritonitis was present. The perforation was closed by suture. Death occurred about two days after the trauma.

CASE 3—A boy, aged 7, was knocked down by an automobile. He was admitted to the hospital six hours after the injury, complaining of abdominal pain, tenderness and intense thirst. The urine was moderately hemorrhagic. Abdominal rigidity was marked. The preoperative diagnosis was "rupture of bladder and fracture of pelvis." A laparotomy was performed shortly after admission. Three perforations of the intestine were found and sutured. The patient died the next day in collapse.

CASE 4—A man, aged 46, was injured in a trolley car collision. He complained of pain in the right lower quadrant of the abdomen, which steadily grew worse. He was admitted to the hospital two days after the accident in severe shock and with marked abdominal distention. A laparotomy was performed shortly after admission, disclosing a fully developed purulent peritonitis. The jejunum showed a perforation on the side opposite the mesentery, 2 cm in diameter. An enterostomy was performed near the perforation. The patient died three days after the accident.

CASE 5—A man, aged 21, was crushed between two cars. He was admitted to the hospital in a marked state of shock and with a painful and tender abdomen. A laparotomy was performed shortly after admission. A complete cross tear of the jejunum was found, with a 4 cm mesenteric tear at a point 40 cm below the ligament of Treitz, 40 cm below this were two areas in which about 15 cm of the small intestine were free of mesentery. A partial enterectomy and an entero-enterostomy were performed. The patient died after two days of an acute suppurative peritonitis.

## CASES IN WHICH RECOVERY TOOK PLACE

CASE 6—A man, aged 26, was injured in a collision of a taxicab with a wagon. He was admitted to the hospital immediately after the injury, with sharp pain in the left side of the abdomen and an abrasion over the left flank. Laparotomy was performed shortly after admission. A perforation of the small intestine, 1 cm in diameter, was found. This was closed, and drainage was instituted. After operation, the patient passed much gas by rectum for

bones of the left leg were fractured. A laparotomy was performed the same day. The lower pole of the spleen was torn across, and there was bleeding into the splenic pedicle. The spleen was removed. Death occurred fifteen hours after the injury from secondary anemia, due to the primary internal hemorrhage.

CASE 4—A man, aged 60, while in an alcoholic state, was run over by a wagon. He walked home and some time later collapsed in his bathroom. He was admitted to the hospital twelve hours after the accident, complaining of pain on respiration, anemia and a distended and tender abdomen, especially in the left upper quadrant. Splenectomy was performed eighteen hours after the trauma, and blood was removed. Transverse ruptures on the surface of the hilum were found. Death occurred four days after the accident from lobar pneumonia. A small subcapsular rupture of the left kidney was found, but was not of great significance.

CASE 5—A boy, aged 13, while coasting down a hill, struck a stone wall. He was able to walk, though he complained of pain in his left side. He was admitted to the hospital thirty-three hours after the accident, complaining of pain in the left side, especially on respiration. Shifting dulness was present in the flanks. A laparotomy was performed one hour after admission and thirty-four hours after the injury. A small rupture of the anterior edge of the spleen was found. The spleen was not removed, as the rupture was not bleeding. About 140 cc of blood was present in the abdominal cavity, and this was removed. The patient recovered in ten days, without any sequelae.

CASE 6—A girl, aged 7, fell against the corner of a desk. She walked home and later vomited. She was admitted to the hospital four hours after the accident, suffering from abdominal pain. The upper left abdominal quadrant was rigid. Dulness was present in the flanks. Splenectomy was performed five hours after the accident. An abdominal hemorrhage and a stellate laceration of the spleen were found. Recovery occurred in thirty-five days without any sequelae.

CASE 7—A boy, aged 13, was run over by a wagon. He entered the hospital in severe shock, but was not unconscious. He was pale and suffering from thirst. The upper part of the abdomen was rigid. The spleen was removed at laparotomy shortly after admission, and was found fragmented. Blood was present in the abdominal cavity. Recovery occurred in thirty-four days, without any sequelae.

CASE 8—A boy, aged 17, was crushed in the region of the lower part of the chest. He was admitted in a state of shock, he was pale and drowsy and complained of severe pain in the abdomen. Splenectomy was performed shortly after admission. Hemorrhage was present in the abdomen. The spleen was ruptured on the surface of the hilum. The patient recovered in sixteen days.

CASE 9—A man, aged 23, fell 30 feet down an elevator shaft. He was admitted to the hospital in a semistuporous condition and in a state of shock, with a tender left flank and a rigid abdomen. Luxation of the left shoulder joint was present. Splenectomy was performed shortly after admission, and the luxation was reduced. A transverse laceration of the spleen was found. Blood was present in the abdomen. Recovery occurred in twenty-seven days.

CASE 10—A man, aged 29, was struck by an automobile one-half hour prior to admission to the hospital. He was admitted in a state of shock with a rigid abdomen and shifting dulness in the left flank. He complained of pain in the left upper abdominal quadrant. Splenectomy was performed shortly

of varying grades of severity. Patients 3 and 5 showed more or less shock after the injury, the laparotomy was done shortly after the trauma, but apparently was not of much avail. Patients 1, 2 and 4 were admitted anywhere from twenty-two to forty-eight hours after the trauma, and a fatal peritonitis was fully developed when the operation was started. The lesions consisted of bursting ruptures in four instances and tearing of the intestine and mesentery in one.

The five patients who recovered varied in age from 26 to 59 years. Some of the injuries were slight, others were severe. The patients were admitted, however, soon after the accident and were operated on within a few hours of their admission. Four of the injuries were bursting ruptures and one was a tear completely through the ileum. Some of the patients showed intestinal contents free in the abdominal cavity at the time of operation, and signs of peritoneal inflammation were present.

Apparently the important factor in treating patients with intestinal injuries successfully is to perform the operation early. Unfortunately, the seriousness of his condition is not always recognized by the patient, and he may not seek medical attention until he is practically moribund. Then, too, because of the vagueness of the early symptoms and the frequent absence of external evidences of violence, the surgeon is prone to overlook the possibility of an intestinal lesion. In several instances, alcoholic intoxication at the time of the accident served to mask the signs of the abdominal trouble. The result is that some patients who might have been saved by prompt surgical measures die because of the delay.

The usual surgical measure is to open the abdomen and close the opening in the intestine. If the perforation is small, this is not difficult. With large openings and mesenteric tears, resection of the intestine around the lesion is sometimes necessary. In cases of severe ileus, an enterostomy is frequently necessary to combat the distention of the intestine.

*Mesentery*—The mesentery is occasionally ruptured subcutaneously, either alone or in combination with the intestine. Two mechanisms have been described: (1) contusion and (2) tearing.

1. In rare instances, a localized violence with a sharply limited area of impact can thrust against the anterior abdominal wall at right angles and crush the membrane against the iliac bones or the lower end of the lumbar spine (Dubs)<sup>40</sup>. If a single layer is involved, a single perforation is produced. If several folds of the membrane are caught, several perforations result. The folds nearest the abdominal wall generally show an opening with ragged and contused edges, about the

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40 Dubs, J. *Deutsche Ztschr. f. Chir.* 151:120, 1919.

spleen would be futile in most cases. The mortality of splenectomy has been estimated at about 34 or 43 per cent, which agrees with the results in this series.

In the literature,<sup>24</sup> a splenectomy is said to be followed often by some distinctive changes in the blood, the lymph nodes and the thyroid gland. These changes are not constant, however. Swelling of the thyroid has been mentioned, but at present its connection with the removal of the spleen is considered dubious. Pain in the long bones has been occasionally observed. Enlargement of the lymph nodes, especially the supraclavicular, cubital and inguinal groups, has been noted more often, but does not always occur.

The changes in the circulating blood are sometimes pronounced, but at other times are well within the normal variation. The red blood cells may be decreased in number or increased above the usual limits. The hemoglobin may be diminished, and the red cells may appear pale and show the changes of secondary anemia. The leukocyte count may vary from the normal limits to from 40,000 to 60,000. In some instances a marked lymphocytosis, as high as 44.75 per cent, a slight eosinophilia, and a rise in the proportion of blood platelets are present, but these manifestations are not invariably present. All that can be said at present is that the removal of the spleen creates distinct disturbances of a minor nature in the lymphatic hemopoietic system that may be manifested in the manner described. In the series of cases described here, these phenomena were not observed.

In the four fatal cases, death was caused either by the intra-abdominal hemorrhage or by intercurrent infections, which were furthered by the secondary anemia from the hemorrhage. In general, the trauma was severe and other injuries, such as a fractured femur or a ruptured left kidney, contributed appreciably to the fatal result.

#### KIDNEYS

The kidneys are not so commonly ruptured by blunt force as either the liver or the spleen. Geill<sup>1</sup> mentioned that such injuries comprised 21.5 per cent of all visceral injuries in his collection. As a rule, the lesion is unilateral, and it is rare to find both kidneys involved in the same case.

Their anatomic position in the body explains many peculiarities of the rupture. They are paired organs, lying deep in each lumbar fossa at about the level of the second lumbar vertebra. The blood vessels and ureter enter the hilum, which is placed in the midportion of the internal edge of each. Posteriorly, the right and left twelfth rib cross the middle portion of the corresponding kidney obliquely. Anteriorly, they are covered by a layer of peritoneum, and the greater part of the organ is definitely retroperitoneal.

abdominal wall, just to the inner side of the cecum. The anterior surface of both thighs presented considerable bruising, and a contusion was present on the back of the right hand. It was obvious that the man had been in an accident and had probably fallen heavily against a projecting object.

2 More commonly, the mesentery is torn by an indirect violence which acts tangentially on the abdominal wall and exerts traction on the membrane. This mechanism had already been considered in the tears of the mesentery and intestine combined. The same force can act on the membrane alone and can produce either huge isolated ovoid openings or multiple smaller openings. All grades of the lesion occur. Complete tears involving both layers are the most common, but partial rips, which involve only one side of the membrane, have been seen. Both may be present in the same case. Occasionally, the intestine may be stripped from the mesenteric attachment, as described by Dubs<sup>41</sup>.

The casualty that is most commonly responsible for this lesion is the highway accident. The wheel of an automobile grinds the body and exerts traction on the membrane. Less often, a localized violence which ploughs its way over the anterior abdominal wall will produce a similar effect. Figure 8 shows an example of this type of force. A man, aged 33, while seated on his truck, ran into the end of a projecting pole from another vehicle and forced it tangentially over his abdomen.

The mesentery of the small intestine is most often injured, especially at the cecal end. Less often, the mesosigmoid, the mesocolon transversum, the omentum and the meso-appendix are involved. The usual result is an intra-abdominal hemorrhage. If the big vessels at the root of the mesentery are torn, the bleeding is rapid and is followed by death in a few minutes. More often the bleeding is slower, and the hemorrhage may be prolonged for hours and even days. An associated intestinal perforation will result in a fatal septic peritonitis.

Another complication is introduced when the rupture occurs adjacent to the intestinal insertion. Here the arterial vessels are end arteries, so that a mesenteric injury of any size will interfere with the blood supply of the intestine at this point. If death does not occur from hemorrhage in the course of one or two days, necrosis and gangrene of the affected intestine will result, with the further development of a severe toxic and paralytic ileus, which finally ends in death. The following case illustrates this complication.

A man, aged 36, fell during the collapse of an excavation under a sidewalk. He did not enter the hospital until the second day after the accident and was then suffering from severe abdominal tympanites and was practically moribund. A rapid enterostomy was performed to relieve the distention, but

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41 Dubs, J. *Deutsche Ztschr f Chir* **133** 366, 1915

The lesions can best be classified according to Wagner's<sup>20</sup> scheme

1 Separation of the fatty capsule from the fibrous capsule may occur without rupture of the parenchyma of the kidney. This is caused by a violence which in some way kneads the fat loose, so that a hematoma forms in between the two layers. The blood may be absorbed later and the site of the injury undergo induration of the connective tissue or, if the hemorrhage is a large one, a perirenal pocket of varying size, similar to a bursa will form,

2 Ruptures of the substance of the kidney which do not involve the pelvis or pyramids are often found. They are usually small transverse lesions on the anterior surface of the organ. If the fibrous capsule is torn, a perirenal hematoma, not accompanied by urinary extravasation, is the result. Small tears generally heal with the forma-

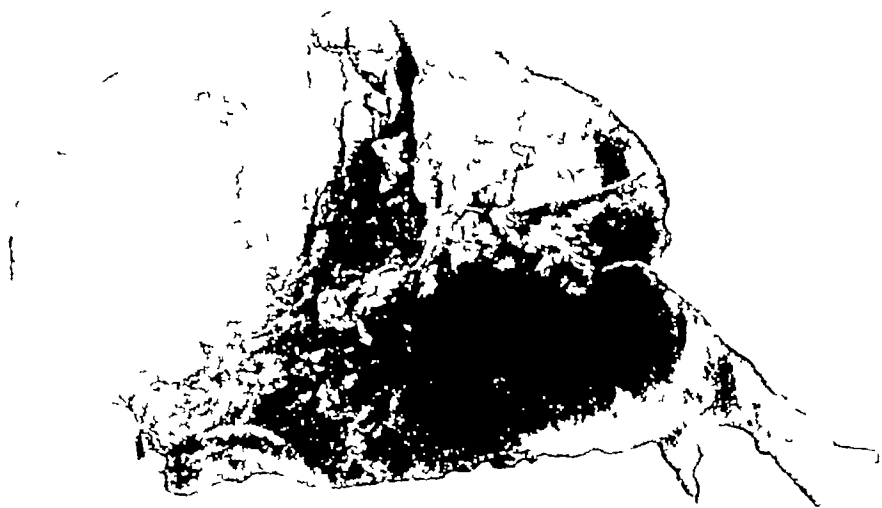


Fig 3—Transverse laceration of kidney

tion of scars. Larger ones may form small traumatic infarcts in the parenchyma. Sometimes the fibrous capsule is uninjured, though the parenchyma may be severely torn. The hematoma may extend to the hilum of the kidney and spread down the spermatic vessels on that side. They have been described as extending to the inguinal ring and pointing into the groin in the course of two or three weeks.

3 Severe ruptures of the kidney, involving either pelvis or pyramids, are occasionally present. They are usually extensive and tend to divide the organ into two parts (fig 3). A perirenal effusion of blood and urine occurs and may reach a large size. The urine excreted through the bladder may be bloody.

4 Some ruptures are extensive and shatter the kidney into fragments. Generally the same complications follow as were described in



another serious visceral injury which could be said to have caused death. The ages varied from 3 to 60 years. Four patients died rapidly, within three hours, of an intra-abdominal hemorrhage, two died of abdominal hemorrhage nine and ten hours, respectively after the accident, one died at the end of four days from the associated gangrene of the ileum and its sequelae, which have already been described.

Three cases showed solitary tears in the mesentery at the lower end of the ileum. The other four tears were multiple and involved the



FIG 9—Perforation of the mesentery of the small intestine with gangrene of the adjacent portion of the intestine

mesentery of the small intestine in all instances and the omentum in three instances. The violence was severe in all cases. Five of the tears were caused by accidents on the street, one from a fall down an excavation, while the other was probably caused by a fall.

An isolated mesenteric rupture was not discoverable in the clinical material, though two tears were found in the ten cases already listed under intestinal injuries, in one of which the outcome was fatal and in the other of which the patient recovered. Because of the intra-abdominal hemorrhage, the mesenteric injuries were outspoken in

peritonitis The mortality is high, though some of the less severe ruptures of this type are not necessarily fatal

The subcutaneous renal injuries described in the records of the necropsies were not especially satisfactory for the purposes of study Most of them were associated with other visceral ruptures and had only a minor influence on the course of events In only two cases, which occurred in children, were the ruptures of the kidney of any special significance In one, the peritoneal reflection was torn and the kidney lacerated in a stellate fashion on its anterior surface, causing a fatal intra-abdominal hemorrhage In the other case, the child was run over by an automobile and the right kidney was split in many pieces, transversely A retroperitoneal pocket was formed, which led from a space around the lacerated kidney into the right side of the chest The result was a fatal hemorrhage into the pleural cavity from the traumatized kidney Other injuries were not present

The clinical records follow

#### CLINICAL HISTORIES

CASE 1—A man, aged 33, was injured when the taxicab in which he was riding collided with a pillar of the elevated railroad He was admitted to the hospital complaining of pain in the right lower quadrant of the chest posteriorly A contusion over the ninth and tenth ribs on the right side posteriorly and a spasm of the right rectus muscle were present The urine was bloody Operation was not performed He recovered in twelve days

CASE 2—A girl, aged 12, scraped her right side while coasting on a sled She complained of tenderness in the left upper abdominal quadrant, blood was present in the urine An operation was not performed She recovered in fifteen days

CASE 3—A boy, aged 9, was struck by an automobile On admission, he complained of pain in the right flank An operation was performed shortly after the injury, by lumbar incision The right kidney was lacerated at the junction of the upper and middle thirds on its anterior surface, the rupture extending to the hilum A similar rupture was present on the posterior surface near the middle of the organ The peritoneum was opened and a little blood removed The lacerations were sutured An uneventful recovery occurred in fourteen days

CASE 4—A man, aged 26, fell from a scaffold, striking himself on the right flank On admission to the hospital, he complained of pain and tenderness in the right side The urine consisted of almost pure blood Operation was performed six hours after the trauma A laparotomy incision in the right rectus muscle disclosed some serosanguineous fluid in the abdomen, a large perirenal hematoma on the right side and an extensively shattered right kidney A nephrectomy incision was made in the right flank and the kidney removed The patient recovered within a month without incident, except for a slight pulmonary infection following the operation

CASE 5—A man, aged 36, fell five stories On admission, he had pain in the right lower quadrant of the chest and was in a state of shock Tenderness to pressure was present over the right flank and the upper part of the

In some fractures of the pelvis, all four pubic rami are fractured and the entire pubis is detached from the rest of the pelvis. If this is forced backward by the violence, the membranous urethra will be torn across close to the prostate.

All three varieties of laceration may occur, either isolated or in combination, depending on the way in which the fracture is produced.

The force required to cause these injuries is necessarily violent, as the pelvis is not easily broken. Consequently, a severe shock results, and the patient often dies of this complication within a few hours of the accident. In some instances the shock is not so severe, and then an extravasation of blood and urine occurs through the lacerations in the wall of the bladder and may reach voluminous proportions. It may fill the perivesical retroperitoneal tissues, run down into the thighs, the scrotum, the perineum, the buttocks or the anterior abdominal wall. The end-result of the process is a gangrenous abscess of the parts involved that is apt to prove fatal through septic infection.

In rare instances, an extraperitoneal rupture may occur without a pelvic fracture. At the moment of trauma, the bladder is in a state of half distention and is acted on by a force that presses on the lower abdominal wall from above downward. The impact is against the fundus and the increased pressure within the lumen is directed most strongly against the base of the organ. The bladder tends to rupture at the various points of lessened resistance in this region, which are the great sciatic foramina, the obturator foramina and the pelvic outlet (Schonwerth)<sup>43</sup>. One case of spontaneous rupture in this region, complicating a chronic urinary obstruction due to prostatic hypertrophy, has been described (Muir)<sup>44</sup>.

2 The intraperitoneal rupture occurs only when the bladder is fully distended by urine. A force applied to the anterior abdominal wall below the umbilicus will compress the posterior part of the fundus against the promontory of the sacrum and raise the pressure inside the lumen. The apex of the sac is thus put under stress and consequently ruptures. In most instances the perforation is found as a longitudinal, ovoid opening, slightly posterior to the apex. Some perforations, however, may be located laterally or even anteriorly. The violence is often slight and, as a rule, the bladder is the only organ injured. In some cases, even indirect violence, such as a fall on the buttocks or a sudden increase in intra-abdominal pressure from muscular action such as lifting a heavy weight, can cause the same lesion (Seldowitsch)<sup>45</sup>.

A large number of spontaneous ruptures at the fundus have been described. In the majority of instances, a predisposing cause has

43 Schonwerth, A. Arch f klin Chir **85** 876, 1908

44 Muir. Brit M J **2** 25 (July 4) 1908

45 Seldowitsch, I. B. Arch f klin Chir **72** 859, 1904

toms are of slight grade and that the patients will recover without operation. It is just as certain that patients with severer renal injuries require operation and that most of them react favorably to this treatment.

#### PANCREAS

Subcutaneous ruptures of the pancreas are rare. Geill<sup>1</sup> alleged that they occur in 4+ per cent of all visceral injuries, and most other authors concur in this view. Boesch<sup>28</sup> asserted, however, that the gland is frequently affected by trauma and sustains many slight contusions which are probably unrecognized during life. This assertion is hard to verify or to disprove, but, in any event, the number of pancreatic lesions that gives rise to definite complications is small.

Normally, the pancreas is placed in a retroperitoneal position with its flat surface closely applied to the posterior abdominal wall. Its longitudinal axis lies in the right and left diameter of the trunk at right angles to the course of the abdominal aorta. Its midportion is in close proximity to the aorta and the body of the second lumbar vertebra. In front, it is covered by that portion of the peritoneum which forms the posterior wall of the lesser peritoneal sac. It is firmly anchored in its bed of adipose tissue and has no range of motion.

The structure of the pancreas is like that of other complicated racemose glands in that it is made up of small lobules separated by a vascular connective tissue which is both loose and tough. The normal organ is not easily lacerated because of its lobulated structure. Furthermore, as it lies at a considerable distance from the anterior abdominal wall, it is not easily reached by any but a violent force.

Practically the only way in which the pancreas can be ruptured is by a violence that directly compresses the lower portion of the epigastrium and crushes the viscus against the body of the second lumbar vertebra.

The object that comes in contact with the abdomen, whether it is the wheel of a vehicle, the hoof of a horse or the end of a wagon pole is in most cases hard and consequently is well fitted to sever the pancreatic parenchyma. Perhaps the majority of ruptures are due to intense localized force inflicted by a hard object.

Boesch<sup>28</sup> asserted that sometimes in children whose chest wall is easily compressible a force applied to the lower portion of the sternum will force the ensiform process downward and backward so that it meets the pancreas violently and contuses it against the spine.

The lesions produced by the violence are of different grades of intensity. The most severe type is the complete division of the gland and its peritoneal layer in the sagittal plane. Most of the lesions

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28 Boesch, F. *Deutsche Ztschr. f. Chir.* 167:282, 1921.

A few cases are described in which the intraperitoneal opening has been closed later, so that the escape of urine into the abdomen was prevented. In one case it was noted that a piece of omentum had been snared in the rupture and had sealed the orifice. In other instances the perforation of the bladder is directed obliquely through the wall, so that the outflow of urine is prevented by a valve action (Nordmann)<sup>48</sup>

Few cases came to necropsy, and, as most of them have been discussed, further detail will not be given.

The clinical records follow.

#### CLINICAL HISTORIES

CASE 1—A man, aged 44, fell to the floor the night before admission while in an alcoholic condition. His abdomen began to swell, he noticed that he could not void urine and vomited considerably. He was admitted about twelve hours after the fall, complaining of abdominal distention and vomiting. The abdomen was tympanitic, with signs of fluid in both flanks. Catheterization yielded a straw-colored urine. He was operated on about ten hours after admission. The abdomen contained from 5 to 6 liters of turbid yellow fluid. A rupture of the bladder, 4 cm long, was found on the posterior part of the fundus. It was sutured, and the patient died two and one-half days later from toxemia.

CASE 2—A man, aged 36, was crushed in an elevator. He was admitted to the hospital in a state of shock, showing multiple contusions of the scalp, pelvis and lower part of the abdomen. Pain and tenderness in the lower part of the abdomen, with some rigidity, were present. He was operated on the day after admission. Clear, colorless, odorless fluid was found in the abdomen, and a rupture of the bladder was found on the posterior portion of the fundus, which was sutured. The appendix appeared inflamed and was removed. The patient died two days after the trauma.

CASE 3—A woman, aged 24, jumped from a third story window while under the influence of alcohol. She was admitted to the hospital the day after the accident in a state of shock and complaining of severe abdominal pain. The abdomen was tympanitic and distended. She said that she could not void. Only a few cubic centimeters of bloody urine were obtained on catheterization. There was a fracture of the right iliac bone and the left thigh, and numerous contusions and lacerations were present over the face, extremities and trunk. An operation was performed two days after the injury. Two quarts (946.2 cc) of straw-colored fluid with a urinous odor was found in the abdominal cavity. The peritoneum was congested, but did not show an exudate. A tear, 2.5 cm long, was found in the fundus of the bladder, which was closed. A suprapubic cystostomy was performed, and a drain was placed between the bladder and the uterus. Recovery was slow, due to the broken bones. The patient was discharged at the end of the second month with only the sequelae due to the broken bones.

In spite of the small number of cases, several points of interest were brought out. One was the association of alcoholic intoxication with

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<sup>48</sup> Nordmann, O. *Deutsche med. Wchnschr.* **34** 144 (Jan 23) 1908.

tion of the peritoneal layer and the gland may not be extensive, and the hemorrhage may be slow. The lesser peritoneal sac will be filled with blood and, if the foramen of Winslow is in any way closed, a massive hematoma or "cystoid" will be formed. The blood will pass, however, into the general peritoneal cavity through the foramen of Winslow if that opening is patent. Occasionally, some of the pancreatic ducts are torn, and pancreatic secretion will be mixed with the blood. Small, chalky white areas of fat necrosis will be more or less widely disseminated through the peritoneal fat (Simmonds)<sup>32</sup> In some instances, the effused blood may become infected and a suppurative peritonitis result.

The greatest interest, however, attaches to those cases in which the peritoneal covering in front of the gland is left intact, while the pancreas and its ducts are torn more or less completely by the violence. A retroperitoneal hemorrhage, of widely varying size and position, then occurs. This finally results in that rare condition known as a traumatic pancreatic cyst.

Two forms of traumatic pancreatic cysts are distinguished: the peripancreatic cyst and the endopancreatic cyst.

The peripancreatic cyst starts to form immediately after the trauma as a huge effusion of blood and pancreatic secretion in the retroperitoneal tissues around the gland. It pushes the peritoneal investment ahead of it as it increases in size until, in a period varying from eleven days to several months, an epigastric swelling is produced that is easily demonstrable on external examination. The contents are at first bloody, but later are digested by the secretion and become clear. A reactive inflammation is set up in the periphery of the effusion, and a thick fibrous wall develops. Microscopic examination of the newly formed capsule discloses the absence of an epithelial lining for the cavity, but demonstrates the presence of necrotic gland lobules and pigment that contains iron in the wall. The clear contents of the cyst usually contain all three pancreatic enzymes.

The development of the cyst is slow and insidious. Generally, the first indications of its presence are a big fluctuating mass in the epigastrium, with progressive loss of nutrition, and numerous signs and symptoms denoting disturbance of pancreatic function, such as anorexia, constipation, glycosuria and fatty stools.

In rare instances, the cyst has eroded the wall of the intestine, and spontaneous drainage of its contents has resulted. In most cases, however, the only relief is to be obtained by operation. Tamponade and drainage of the contents have given the best results. In a few instances, complete removal of the cyst has been tried, but the pro-

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32 Simmonds. *Deutsche med. Wchnschr.* 28:23 (Jan 16) 1902.

# THE ETIOLOGY AND TREATMENT OF SCOLIOSIS\*

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The importance of early and efficient treatment of patients with scoliosis, arises from the extreme uncertainty of their future progress. It is known that in some patients the condition may become spontaneously arrested in an early stage, in other cases, the disease may increase, and may not only produce extreme deformity but seriously impair the general health. The aim of treatment should be to prevent the progress of the deformity, to correct, if possible, the existing deformity and to maintain the correction until all danger of relapse is past. This usually means until maturity is reached.

The correction of spinal curvature requires much attention to detail, and individual adaption of the various procedures, varying largely with the location and degree and, to a lesser extent, with the etiology of the deformity. For this reason it was thought desirable to study a series of cases to determine, as accurately as possible, the predisposing and direct etiologic factors and associated conditions, and to compare the results of treatment by various methods.

As a basis for this study, the clinical records and roentgenologic observations in 125 cases of scoliosis were reviewed. These cases were selected from those observed between the years of 1919 and 1927 by my colleague Dr Willis C Campbell and myself.

Thirty-six of the patients, observed within the past three years have been studied with particular reference to the results of treatment.

## AGE AT ONSET

One hundred and twenty of the patients were white and five were colored, eighty-seven, or 70 per cent, were females and thirty-eight, or 30 per cent, were males. The average age at which the deformity was first noticed was  $12\frac{1}{2}$  years in both male and female patients. The average age at which the physician was first consulted, however, was 14 years for girls and 18 years for boys. This means that parents are more concerned about good figures for their girls than for their boys. Ten patients were under 10 years of age, when first examined the youngest was a child of 16 months with a congenital malformation of the spine. Ninety-seven were in the second decade of life, fifteen in the third decade, two in the fourth decade, and one, the eldest, was a woman of 68, who had had a curvature of the spine as long as she could remember and who sought treatment for rheumatoid arthritis.

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\* From the Willis C Campbell Clinic, Memphis

extravasations Injuries of the pancreas occasionally cause cysts of a peculiar type

Ordinarily, because of the shock and the presence of blood in the abdominal cavity, injuries of the parenchymatous viscera show well marked signs of abdominal distress In some instances the organ may be ruptured by a slight force, and the symptoms may be less outspoken In these conditions diagnosis may be difficult, and it may be none the less difficult because external evidences of violence are often lacking

The injuries are of different grades A large proportion are so extensive as to be almost immediately fatal A few are so slight that they often heal spontaneously In between these extremes are a number of ruptures which would not necessarily result fatally if the patients were operated on and given appropriate treatment, but which would result fatally if the patients were treated expectantly

The surgical problem is not a simple one In a few instances especially in ruptures of the kidney, expectant treatment may suffice Perhaps the safest procedure is to perform an exploratory laparotomy in doubtful cases, if the condition of the patient warrants it, and then let the condition found at operation determine what course is to be pursued

#### INJURIES OF THE HOLLOW ABDOMINAL VISCERA THE STOMACH, DUODENUM, INTESTINE WITH ITS MENTERY, AND THE URINARY BLADDER <sup>35</sup>

The subcutaneous injuries of the hollow abdominal viscera are unlike those of the parenchymatous organs The former are fragile and, for the most part, poorly protected from force applied to the lower part of the abdomen As a result, they may rupture after a slight grade of violence The injury is often solitary and may be attended by a small amount of shock, so that the complications develop insidiously In a large percentage of the fatal cases, death is caused by an acute suppurative peritonitis which results from leakage of the contents into the abdominal cavity A smaller proportion of the patients die of intra-abdominal hemorrhage

The hollow viscera are less frequently injured than the parenchymatous organs, probably because they tend to elude the action of the force In the gastro-intestinal tract, the mobility of the segments enables them to escape the consequences of the trauma in many instances, and it is only in certain conditions that they are especially prone to rupture The urinary bladder is likewise elusive, for in the contracted

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<sup>35</sup> Ruptures of the uterus and adnexa are not included because they are extremely rare in the normal state and usually occur as spontaneous ruptures in organs enlarged by pregnancy or pathologic conditions



der<sup>4</sup> and others have emphasized the laxity of the spinal ligaments, the muscular weakness and the decreased density of bone (4) Lee<sup>5</sup> accounted for the high incidence of the condition in girls at puberty as being due to stimulation of the sacral plexus by pelvic congestion (5) In the series of cases reported by Adams,<sup>6</sup> there was a large percentage with congenital variations of the lumbosacral spine

In this series the etiologic factors which were chiefly responsible for the deformity were in the order of frequency idiopathy, seventy-nine cases, anteriopoliomyelitis, twenty-five cases, congenital anomaly of the bones of the spine, ten cases, empyema, four cases, spastic paralysis, three cases, destructive lesion of the vertebra, two cases, rickets, one case, and torticollis, one case

The cases have been classified in this manner when in the opinion of the observer some etiologic factor was the chief or only factor involved Twenty-eight cases, however, presented a combination of more than one possible cause Twenty-four of these cases, on roentgenologic examination, showed some minor congenital spinal anomaly which in itself was not deemed sufficient to account for the deformity This will be discussed further in the section under congenital scoliosis Two cases classed as idiopathic showed evidence of roughening of the articular surfaces of the vertebra, suggesting epiphysitis or osteochondritis

Two cases presented three possible etiologic factors A man, aged 26, gave a history of typhoid fever and meningitis preceding the deformity This may have been anterior poliomyelitis, but the history of illness was not clear, and residual weakness or atrophy of the muscles was not present The roentgenogram showed a suspicious asymmetry of the bodies of the fourth and fifth lumbar vertebrae, which was considered to be due to rotation, but which might have been a congenital anomaly The case was classed as idiopathic

The second case, that of a girl, aged 11, was also classed as idiopathic The roentgenogram, however, showed large bilateral irregularly formed transverse processes of the fifth lumbar vertebra, and a spina bifida of the first sacral segment There was also slight roughening of the epiphyses of the lower dorsal vertebra, suggesting an epiphysitis

Each of the larger groups of cases will be discussed separately

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4 Scudder, Charles L A Determination of the Muscular Strength of Growing Girls and Its Relation to the Etiology, Treatment and Prognosis of Lateral Curvature of the Spine, *Tr Am Orthop A* 3 84, 1890

5 Lee, Benjamin The Nervous and Muscular Element in the Causation of Idiopathic Lateral Curvature, *Tr Am Orthop A* 3 80, 1890

6 Adams, Z B The Relation of Bony Anomalies of the Lumbar and Sacral Spine to the Causes and Treatment of Scoliosis, *J Orthop Surg* 12 45 1914

posterior walls, at the same level, combined with extensive contusion of the muscular coats. Perforation was not present. Death was due to an associated laceration of the liver in the sagittal plane. This case has already been described. Both injuries were produced by a severe violence which crushed the viscera between the anterior abdominal wall and the projecting lumbar spine.

Tearing of the stomach was found twice. In one case it was complete (fig 5 *B*). A severe tangential violence traveling across the

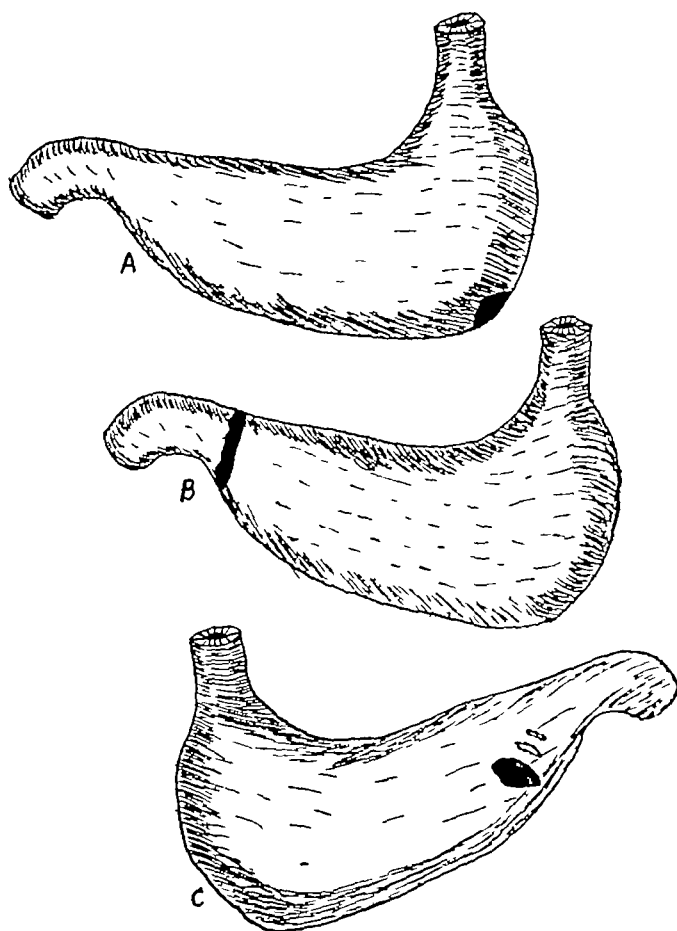


Fig 5—Diagrams showing different ruptures of the stomach. *A*, Bursting rupture of the stomach. *B*, Complete tear of stomach at pylorus. *C*, Partial tears of stomach near pylorus on posterior wall.

epigastrium from right to left had put traction on the pylorus, tearing it transversely across 1.5 cm from the firm duodenal attachment. In the other instances, the tear was partial. The lesion was an elliptic perforation of the posterior wall midway between the pylorus and fundus (fig 5 *C*). This was combined with numerous smaller tears on the mucous and serous surfaces. All indicated the action of a force that passed across the epigastrium from right to left. Because of its

all people Since the percentage in this series is nearly double that found during routine examination, the congenital element must play an important rôle in scoliosis

Of the various anomalies found, spina bifida occulta of the first sacral segment occurred most frequently, thirteen times, or 96 per cent According to Sutherland,<sup>8</sup> spina bifida is found during routine examination in 5 per cent, therefore, the percentage of cases of scoliosis in which spina bifida is present is likewise nearly twice as large as the number found during routine examination

In six cases there were six normally formed lumbar vertebra In six cases there was asymmetry of the lumbosacral joint, and in three cases the transverse processes of the last lumbar vertebra were enlarged and of irregular shape Wedging of the bodies of the vertebrae was noted in six cases Cervical ribs were present in five cases, unilateral in

Combination of Congenital Spinal Anomalies with Other Etiologic Factors \*

	Spina Bifida	Lumbo- sacral Asym- metry	Irregular Trans- verse Processes 5th Lumbar Vertebra	Cervical Ribs	Wedge- Shaped Bodies	6th Lumbar Vertebra	Numerical Variations of Ribs
Idiopathic	8	3 } 1 } 4	1 } 2 } 3	1 } 2 } 3	2 } 3 } 5	4 } 1 } 5	
Anterior polio- myelitis	3					1	
Empyema	1						
Congenital	1	2		2			6

\* The numbers in bold faced type represent cases with more than one spinal anomaly present, total 33 cases, 44 congenital anomalies

two and bilateral in three The anomaly was considered as contributing to the scoliosis only in the unilateral cases

Ten cases were undoubtedly caused by congenital malformation of the axial skeleton Of these, four were in males and six in females In five the deformity was noticed at or soon after birth, and in five it was not discovered until later in life The average age at which examination was made was 13 years A brief description of the congenital cases follows

CASE 1—A man, aged 24, had a mild right dorsal curve which had been present since birth Roentgen-ray examination showed a large cervical rib on the left side

CASE 2—A boy, aged 7, had a severe right total scoliosis from the lower cervical region to the sacrum The roentgenogram showed that there were ten ribs on the right and twelve ribs on the left side There was synostosis between the three lower ribs on the left This patient also had a supernumerary thumb on the right hand

8 Sutherland, Charles G A Roentgenographic Study of Developmental Anomalies of the Spine J Radiol 8 357 1922

the pelvic floor. It is profruded against the anterior abdominal wall by the projection of the lower end of the lumbar spine. The large intestine is less exposed. The ascending colon, the descending colon and the sigmoid are placed well back in the lumbar fossa. The transverse colon crosses the front portion of the abdomen, but it is vulnerable only at the midline of the trunk, where it may be crushed between the anterior abdominal wall and the bodies of the lumbar vertebrae. For this reason, the injuries of the large intestine are much fewer than those of the small intestine. Berry described 177 injuries of the small intestine and 15 of the large intestine.

As the tears of the intestines are frequently produced by the same mechanism that tears the mesentery, it is convenient to consider them together. The resulting lesions depend on the way in which the violence is applied. A force that pulls the intestine in the direction of its long axis may snap it completely across, and then may continue the tear into the mesentery, producing a slit that runs toward the base of the membrane.<sup>36</sup> Traction exerted in the line of the vascular supply of the mesentery, away from the base and across the intestinal tube tends to tear large ovoid spaces in the membrane and may crush or cause a partial tear of the intestinal wall. Partial tears can occur from traction applied either in the long axis or in the transverse axis. Needless to say, all varieties and combinations of tears occur.

Seven tears of the small intestine were found in the material obtained at necropsy, five of which were partial and two complete. The accidents were caused by automobiles in four cases, street cars in two cases and a blow from a falling stone in one case. The complete tear is found for the most part in the upper portion of the jejunum a few inches distal to the ligament of Treitz, where the intestine is firmly fixed to the posterior abdominal wall. Immediately after the trauma the circular muscle in the severed ends firmly contracts and prevents leakage of the contents into the peritoneal cavity. After several hours have passed the muscle relaxes and the contents escape. Death occurs either in the early stages from hemorrhage from the torn mesentery or in the later stages from peritonitis which is almost certain to follow leakage of the contents.

Partial tears are frequently seen as large ragged ovoid perforations on the peritoneal surface of the intestine. Often the serous layer is stripped in a zone around the hole through the muscular layer. In one case of this kind an *Ascaris* worm was present in the intestine near the perforation and had been severed by the violence (fig. 6).

Contusions occur in various forms and may be of all grades of severity. If the force is a localized one with a small area of impact the intestine may be perforated by the direct violence and may show

in the length of the legs. This inequality varied from  $\frac{1}{4}$  to  $\frac{3}{4}$  of an inch. Scoliosis does not, as a rule, follow inequality in the length of the legs. It is not uncommon to find an otherwise normal person with shortening on one side. On the other hand, in many cases of extreme scoliosis there is no inequality. In many cases with extreme inequality,

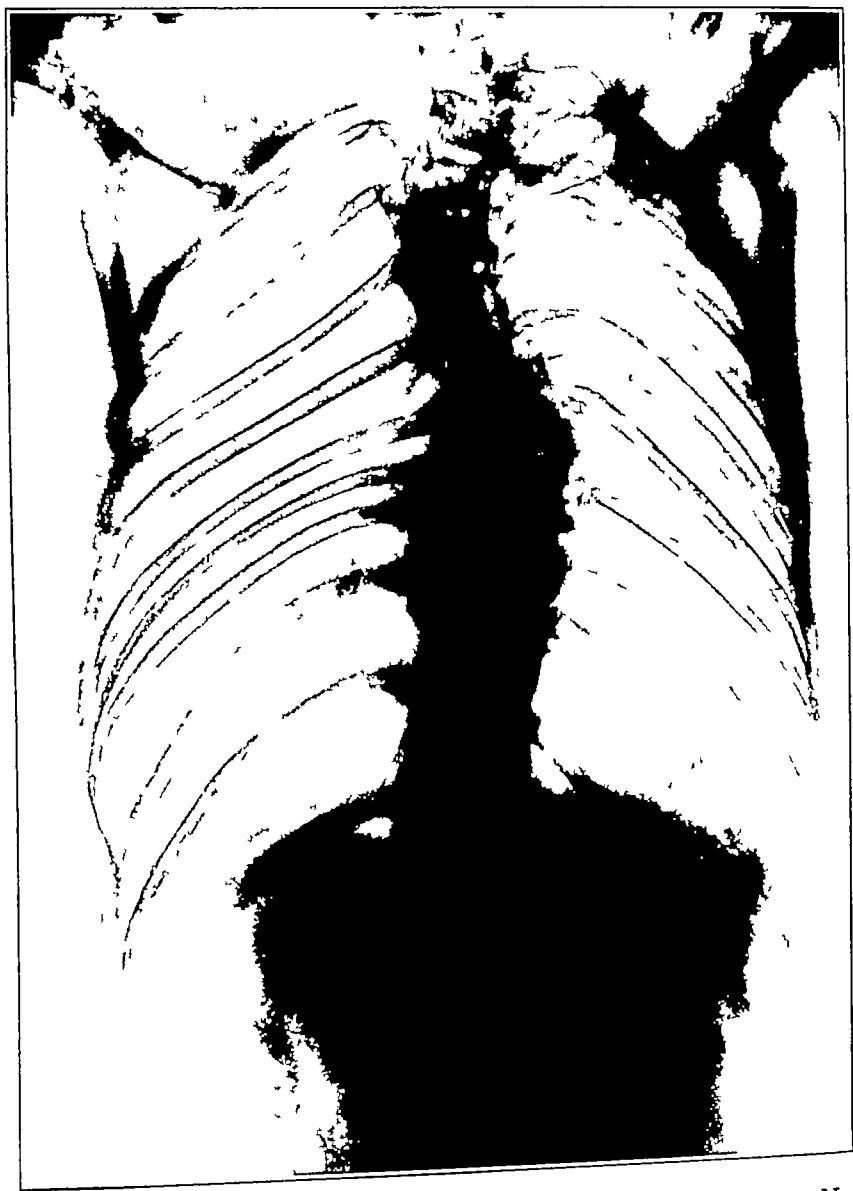


Fig. 1 (case 6)—Roentgenogram showing congenital scoliosis. Note the absence of the left half of the first dorsal vertebra, and the first and ninth ribs.

as in infantile paralysis, there is no fixed deformity of the spine. There is a tilting of the pelvis when the patient stands and a compensatory lateral curve of the spine which disappears, however, on sitting or lying.

Flatfoot, of a degree severe enough to demand treatment, was observed only six times in the nonparalytic cases. Kyphosis round

Sauerbruch<sup>38</sup> asserted that the force imprisons a coil, prevents its contents from escaping and causes the rupture by a sort of hydraulic action. Haim<sup>39</sup> said that any sudden contraction of the abdominal cavity, whether due to violence or even to muscular action, will cause a rise of pressure inside the intestine and that bursting will occur where the wall is weakest. The presence of a hernial sac always aids in the production of this lesion, as the coverings of the sac are too weak to support the intestinal wall against the explosive force within its lumen.

Spontaneous ruptures of the gastro-intestinal tract are of the bursting variety. Any process that weakens the wall, such as an ulcer or an area of necrosis, will predispose to the perforation. This condition, however, belongs to the category of an erosion rather than that of rupture. The best example of a spontaneous rupture, perhaps, is to be found in intestines incarcerated in hernial sacs, in which the vitality of the wall has been so diminished that even mere attempts at reduction cause an explosive perforation.

A study of the material obtained at necropsy (including twelve cases reported by Vance<sup>36</sup>) showed a total of twenty-four cases of ruptured intestine. The duodenum was involved in three cases and the small intestine in twenty-one. The three duodenal injuries were caused by contusion, tearing and bursting. The injuries of the small intestine were caused by contusions in two cases, tearing in seven cases, and bursting in twelve cases. In this list the ruptures caused by bursting outnumbered the contusions and tears combined, which suggests that such ruptures are certainly more common than has hitherto been supposed. As they can be produced by a slight trauma, the numerical preponderance of this type is a matter of some importance.

The trauma was generally a slight localized violence applied to the lower part of the abdomen. The casualties were caused by automobiles in one case, kicks in the abdomen in two, falls in three, a thrown missile in two, and an unascertained injury of slight grade in four. An inguinal hernial sac was present in six of the twelve cases and undoubtedly favored the production of the lesion.

Injuries of the large intestine and appendix were not found. In one instance a mucocele of the appendix had been burst by a slight trauma, and the abdominal cavity contained a handful of clear jelly-like mucin. The appendix, however, was markedly distended and the rupture was really spontaneous.

Reports of ten clinical cases were collected, five in which death occurred and five in which recovery took place.

38 Sauerbruch. *Mitt. a. d. Grenzgeb. d. Med. u. Chir.* **12** 92, 1903.

39 Haim, E. *Arch. f. klin. Chir.* **93** 685, 1910.

on thirty-three patients in this series, five of whom were later operated on. As designed by the originators, it is most efficient in those cases in which there is a single curve at the dorsolumbar region. In cases of double curves, it has been demonstrated, however, that by correcting the dorsolumbar curve, compensatory curves above and below may be lessened. The cast may be extended to the knee on the convex side for correction of the lumbar curves.

The cast from chin and occiput to pelvis to be applied under traction on a special frame, described by Hibbs,<sup>11</sup> is undoubtedly the most efficient method for correcting high dorsal curves, and in this series it has been



Figure 2

Fig. 2—Correction of scoliosis by turnbuckle cast



Figure 3

Fig. 3—Correction of scoliosis in cast applied on Hibbs' traction frame. Note the canvas band for lateral traction.

reserved for that type of deformity. Eleven patients have been treated by this method, seven of whom have been fused.

Four patients were treated by fenestrated casts and pads, three of whom were operated on.

Since the upright position favors the progress of the deformity, we believe that recumbency is an important factor in treatment. This is of course essential to the Whitman method, but when practical, we

<sup>11</sup> Hibbs, Russel A. A Report of 59 Cases of Scoliosis Treated by the Fusion Operation. *J. Bone & Joint Surg.* 6:3, 1924.

four days. The drainage tract discharged foul material for about ten days. The patient fully recovered within one month after operation, without sequelae.

CASE 7—A man, aged 29, was struck in the right lower quadrant of the abdomen by a piece of wood thrown from a circular saw. He was admitted to the hospital complaining of pain over the abdomen. A laparotomy was performed shortly after admission. The abdominal cavity contained much content from the small intestine, with an abundant fibrinous deposit on the serous surface. About 2 cm from the cecum was a small perforation of the ileum, 3 mm in diameter. This was closed by suture. A jejunostomy was performed, and a catheter was inserted through an artificial opening because of the distention. A toilet of the peritoneum was performed. The patient was very ill for the first few days after the operation, but recovered in one month without sequelae.

CASE 8—A man, aged 36, was crushed by a trolley car. On admission to the hospital, he was in a state of shock, with evidence of fractured ribs on both sides and a rigid and distended abdomen. A laparotomy was performed immediately. An oval opening, about 1.5 by 1 cm, in the ileum was found and sutured. After a stormy convalescence from an injury in the right side of the chest, the patient recovered in forty-three days.

CASE 9—A man, aged 59, while lifting a barrel of apples, was suddenly seized with severe knifelike pains in the abdomen. He was admitted to the hospital with rigidity and tenderness over the abdomen. A laparotomy was performed several hours after admission. Much turbid brown fluid was found in the abdomen, and a definite fibrinous peritonitis was present. A perforation of 1 cm of the small intestine was discovered and sutured. An enterostomy was performed with a catheter about 15 cm proximal to the perforation. An uneventful recovery occurred after thirty-eight days, without sequelae.

CASE 10—A man, aged 52, was crushed between a truck and a box car. He was able to walk after the accident. He was admitted to the hospital complaining of severe cramplike pain near the umbilicus and much abdominal distention. An incarcerated scrotal hernia was found on the right side. A laparotomy was performed shortly after admission. The ileum was completely divided with a laceration 4 cm long into the mesentery which was situated about 10 cm from the ileocecal valve. Much blood and fecal material was present in the abdomen and was removed by suction. Paul tubes were put in the severed ends of the small intestine. Eight days after the operation the two ends of the intestine were closed by suture and a drain was put in. Recovery was slow and lasted fifty-eight days. The fistula was at first fecal, but cleared up during the first month after discharge. A ventral hernia persisted however.

These cases illustrated the usual clinical signs of the ruptured intestine. In general, they showed a moderate grade of shock with well marked signs of peritoneal irritation which grew progressively worse. Pain, tenderness, distention and rigidity of the abdominal wall were the chief indications of the rupture. External wounds of the abdomen were not present, and in only two instances were signs of any external trauma present on the body.

Of the ten patients five died and five recovered. The patients who died varied in age from 7 to 65 years. They had suffered casualties



fusion, the Albee graft and the Hibbs' technic, are both unsuitable in scoliosis. The straight rigid Albee graft is difficult to adapt to the curve of the deformity. In Hibbs' operation, the laminae and articular facets are difficult to reach on the concave side. It has been our experience that an osteoperiosteal graft from the tibia was the most satisfactory method. This may be combined with the Hibbs' operation and supplies a large mass of new bone which is flexible and easily accommodated to the area of deformity. The osteoperiosteal graft was used in eight of the ten cases in which operation was performed, in two cases with prominence of the ribs, a portion of the rib was resected and used as an additional graft in combination with the Hibbs' fusion.

As in all operations on the spine, fusion is often accompanied by some degree of postoperative shock. This can be best prevented by the preliminary adjustment of the patient in the prone position on sandbags, so that the respiration, already limited by the deformity, is not further impaired. Stimulants are frequently necessary and should be readily available. There have been no deaths in this series.

A brief summary of the cases in which operation was performed follows.

**CASE 1—Paralytic scoliosis.** A youth, aged 19, was examined Sept. 30, 1921. He gave a history of infantile paralysis at 2 years of age. Examination showed an extreme right dorsal, left lumbar scoliosis. Fenestrated casts were applied to correct the deformity. On March 1, 1922, the spine was fused, the Hibbs' technic being used and a segment from the fourth rib as a graft. The result has been good. Fusion of the spine was solid.

**CASE 2—Paralytic scoliosis with congenital anomaly.** A boy, aged 13, was first seen April 2, 1923. The deformity followed anterior poliomyelitis at 4 years of age and was progressing rapidly.

The examination showed a severe total curve convex to the right. There was marked rotation of the bodies of the dorsal vertebrae with an angular projection of the ribs on the right side posteriorly. The right side of the chest was narrowed, and the right shoulder was higher than the left. The roentgenogram showed in addition to the deformity, six lumbar vertebrae and a spina bifida of the first sacral segment.

Traction by the Whitman method on a curved Bradford frame was applied for eight weeks, further correction was secured by fenestrated casts. On August 22, the spine was fused from the sixth dorsal to the first lumbar vertebrae. In addition to Hibbs' technic, a 2 inch (5 cm.) section was removed subperiosteally from the prominent portion of the sixth, seventh and eighth ribs. This bone was fragmented and placed in the graft bed. The wound healed promptly, and eight weeks later, the boy was up, wearing a spinal brace.

The result has been excellent. When observed in June, 1927, the fused area of the spine was solid. The contour of the spine was much improved, and there has not been any increase of the deformity.

**CASE 3—Paralytic scoliosis.** A girl, aged 19, was examined May 22, 1925. She had had an anterior poliomyelitis at the age of 10, and the deformity of the spine had been noticed a few months later. She had worn plaster of Paris jackets for two years, but in spite of this the deformity was progressing, and she

size and shape of the object that has caused the trauma. The other folds show perforations of somewhat smaller diameter, and the one farthest away from the point of violence may be lacerated only on the surface that happened to be presented anteriorly. With this mechanism, a mesentery heavily interlarded with fat is more prone to rupture than one that is thin and lax.

The ruptures represented in figure 7 were in all probability produced by this type of violence, though a complete history of the casualty



Fig 7—Perforations of the mesentery of the small intestine due to a severe contusion

could not be ascertained. A man, aged 45, was found unconscious on the sidewalk. On admission to the hospital, a diagnosis of acute alcoholism was made, and the presence of an abdominal injury was not suspected. The patient died nine hours afterward. At necropsy, the abdominal cavity was found full of blood and blood clot, the mesenteric lesions were also discovered and were obviously the source of the hemorrhage. An area of contusion was also present in the fat of the anterior abdominal wall, just above the umbilicus and also on the posterior

complained of constant pain in the lower part of the spine, referred about the right iliac crest. The spine showed a marked total scoliosis convex to the right. The right leg was one half inch (1.27 cm) shorter than the left, and both legs showed muscular atrophy and weakness.

On July 29, after six weeks' preliminary traction on a curved Bradford frame, a Hibbs' fusion operation was performed from the seventh dorsal to the second lumbar vertebra. This operation checked the progress of the deformity, but pain persisted. On Dec 1, 1926, she returned for a second operation, at which time the spine was fused from the second lumbar vertebra to the sacrum, an osteoperiosteal graft from the tibia being used.



Figure 7



Figure 8

Fig 7 (case 5) —Before treatment

Fig 8 (case 5) —After correction of deformity of legs and fusion of spine

Roentgenograms made on April 4, 1927, showed solid fusion of the spine from the eighth dorsal vertebra to the sacrum. The contour of the back was good and the pain was much less, though she still had an occasional pain on the right side.

**CASE 4—Destructive lesion.** A girl, aged 10, was first examined on June 16, 1921, for kyphoscoliosis. The child complained of pain in the back and tired easily. Roentgen-ray examination of the spine showed wedging of the body of the twelfth dorsal vertebra, fusion of the bodies of the first and second lumbar vertebrae and irregularity in outline of the bodies of the remaining lumbar vertebrae. A plaster of paris cast was applied, but treatment was soon discontinued.

On May 21, 1925, she returned for observation. The deformity had increased and the pain was more severe. Examination showed a right dorsal left lumbar curve with a rounded kyphos in the lumbar spine. The roentgenograms were similar to those previously made and did not show any increase in destruction in the vertebral bodies. The impression was that the condition resulted from a low

without avail. The patient died two days later. At necropsy, a perforation of the mesentery, 6 cm in diameter, was found adjacent to the ileum about 20 cm from the cecal junction. The intestine adjacent to the perforation was dark and gangrenous, as indicated in figure 9. That portion of the small intestine distal to the injury was contracted, while the proximal portion was massively distended and in a state of acute ileus. The abdominal cavity contained about a pint of discolored blood and blood clot. Death was obviously the result of the toxic ileus.

Cases have been described in the literature in which a mesenteric rupture of this sort, too small to produce gangrene, has caused a chronic



Fig 8—Multiple tears of the mesentery of the small intestine.

stenosis of the intestine after a lapse of several months. The process seems to be dependent on the fact that the blood supply of the stenotic area has been curtailed by the lesion in the mesentery. An inflammation of the connective tissue takes place in the intestine causing fibrosis and shrinking of the wall and narrowing of the lumen to a small caliber. A chronic obstruction is the result which can be remedied only by resection of the stenotic area (Dubs<sup>40</sup> and Maier).<sup>4</sup>

In the material obtained at necropsy, only seven cases out of ninety or 97 per cent showed mesenteric tears that were not associated with

spinal fusion was performed on Jan 14, 1927. An osteoperiosteal graft was placed from the fifth dorsal to the first lumbar vertebrae.

Two weeks after operation, another cast was applied, and later a spinal brace.

The contour of the spine was much improved and the progress of the deformity was checked.

#### CONCLUSIONS

1 The etiology, in the majority of cases of scoliosis, is still obscure. In a study of 125 cases, 61 per cent were of the idiopathic type.

2 The treatment, if successful, must be adapted to the individual case.

3 Fusion of the affected region of the spine offers a practical and efficient method of preventing the increase of the deformity. It is advised in all paralytic cases and in other cases in which progress of the deformity is anticipated.

4 Careful preoperative correction is essential.

5 The use of the osteoperiosteal graft in fusion, is most satisfactory.

their abdominal manifestations, though, as has been shown, this does not necessarily occur in all cases. They present the same difficulties of diagnosis that have been noted in other abdominal injuries.

The only treatment for patients who have these lesions is to operate, tie the torn vessels and, if necessary, resect adjacent portions of the intestine so as to prevent the onset of gangrene in that area. Expectant treatment is of no avail.

*The Urinary Bladder*—Subcutaneous ruptures of the urinary bladder are described as being relatively rare. Geill<sup>1</sup> found only 4.4 per cent in his collection of reports of visceral injuries.

The anatomic position of the urinary bladder in the abdomen and the changes in relationship to the surrounding structures that it undergoes during contraction and distention explain many peculiarities of ruptures of the bladder. In the fully contracted state, it lies entirely extraperitoneally and is fully protected by the strong bony ring of the pelvis. In this state it is most often injured by blunt force which fractures the pelvis. As the bladder fills with urine, it projects above the pelvic ring and finally, in a condition of full distention, occupies most of the lower part of the abdomen and is invested by peritoneum on its posterior and superior surfaces. Its fundus is placed between the promontory of the sacrum and the anterior abdominal wall. In this position, it is especially vulnerable to any violence that may be applied to the lower part of the abdomen.

The ruptures of the bladder are classified most conveniently as (1) extraperitoneal and (2) intraperitoneal.

1. The extraperitoneal ruptures are of two types: those associated with fractures of the pelvis and those which occur without pelvic fractures. The first subdivision is the more common and comprises lacerations inflicted on the wall of the bladder by the sharp ends of the broken pelvic bones. The location of the lesion depends entirely on the site of the fracture. At the time of injury, the bladder either is empty or contains a small quantity of urine.

A common location for an extraperitoneal tear is on the anterior wall near the midline, half-way between the fundus and the urethra. The violence first causes a fracture of the pubic ramus and depresses the sharp ends of the broken bones backward. The sharp inner fragment of the superior ramus lacerates the anterior surface of the viscus, and a big ovoid hole into the cavity is the result.

A second site of these ruptures is usually on the posterior lateral wall, a few centimeters above and behind the ureteral orifice, immediately in front of the corresponding sacro-iliac articulation. When this joint is luxated by the violence a forward projection of the sharp sacral segment will generally perforate the bladder in this region.

## HISTORICAL

No attempt was made to collect a group of these cases for study until 1890. Courvoisier<sup>1</sup> at that time reviewed twenty-four cases of hepatopleural and hepatobronchial fistulas reported in the literature. Six of these patients were observed only during life, but the clinical picture was beyond mistake. The other eighteen fistulas were studied at postmortem examination as well. Cayley's<sup>2</sup> patient had only a hepatopleural fistula. Legg's<sup>3</sup> patient had a hepatopleural and a pericardial fistula. In Pasturaud's<sup>4</sup> case, a subphrenic abscess ruptured into the bronchi, but mention is not made of bile in the sputum, and postmortem examination showed that the liver tissue was not involved. In Riedel's<sup>5</sup> case, an abscess of the liver perforated the abdominal wall, the pleural cavity and the transverse colon, but a pulmonary fistula was not found. These cases do not fit our definition and will consequently be omitted. In 1897, Graham<sup>6</sup> added two of his own reports to the literature, and summarized an additional nine which had been published since Courvoisier's work. Ido and Yasuda<sup>7</sup> made a comprehensive review of the literature up to 1912, and succeeded in compiling reports of forty-eight cases of biliary pulmonary and pleural fistulas in addition to their own. In 1923, Oliani<sup>8</sup> brought the number of these cases reported up to sixty-three. His excellent paper included discussions of biliary pulmonary fistulas due to every cause, over 40 per cent being of echinococcus origin. The case summaries of the latter class of fistula and those due to amebic abscess have been omitted from this review, as they concern more properly tropical or subtropical regions. Biliary pulmonary fistulas due to echinococcus disease are numerous, probably out-numbering all other causes combined. Sendler<sup>9</sup> found a total of sixty-eight cases due to this cause. Smitten<sup>10</sup> found seventy-one cases of hepatopleural and bronchobiliary fistulas, only four being reported from his native country (Russia). He added two of his own cases to this series. In sixty-one of these seventy-three, the sinus led into the bronchi and in twelve into the pleural cavity. A majority

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1 Courvoisier, L. G. *Casuistisch-Statistische, Beitr. z. Path. u. Chir. der Gallenwege*, 1890, p. 111.

2 Cayley, W. *Tr. Path. Soc., London* **17** 160, 1866.

3 Legg, J. W. *Tr. Path. Soc., London* **25** 133, 1874.

4 Pasturaud. *Bull. Soc. anat. de Paris* **49** 189, 1874.

5 Riedel. *St. Peters med. Wchnschr.*, 1885, p. 157.

6 Graham, J. E. *Brit. M. J.* **1** 1397, 1897.

7 Ido, Y., and Yasuda, S. *Beitr. z. path. Anat.* **52** 577, 1912.

8 Oliani, E. *Ann. ital. di chir.* **2** 1075 and 1288, 1923.

9 Sendler, O. *Ein Fall von Leberbronchusfistelbildung durch Echinokokkus entstanden und durch Choledochussteine kompliziert*. Jena, A. Kampfe 1910, p. 45.

10 Smitten, A. G. *Russk. Klin.* **7** 252, 1927.

weakened the bladder wall, such as chronic obstruction to the outflow of urine referable to prostatic hypertrophy or to an old urethral stricture. In other cases, the wall of the bladder may be definitely weakened by a neoplasm, tuberculosis, lipomatosis, ulceration of any sort or trophic changes that result from diseases of the central nervous system. In a state of distention, rupture can occur from such slight stress as would be furnished by a sudden movement or straining at stool (Dittrich)<sup>46</sup>

Occasionally the intraperitoneal rupture is associated with a fracture of the pelvis, though this is merely an accessory action of the violence and has no direct effect on injury of the bladder. Two cases of this sort were noted, both the result of injuries received in automobile accidents. In one the left acetabulum was broken, and in the other the pubic bones were separated at the symphysis. The bladder in the latter case is shown in figure 10.



Fig. 10—Intraperitoneal perforation of the fundus of the urinary bladder.

At necropsy the bladder is found markedly contracted with the opening at the fundus plainly visible. The abdomen is generally full of urine, which is sometimes clear and sometimes tinged with blood. In a patient who died shortly after the trauma, the serous surface may be unchanged. If from two to three days have elapsed however, the peritoneum is generally reddened and congested and shows a low grade inflammatory reaction. According to Rost,<sup>47</sup> much of the urine is absorbed from the abdominal cavity and the patient may die of uræmic symptoms. In other instances, bacteria may gain entrance by way of the perforation in the bladder either from urine primarily infected or from the injudicious introduction of a contaminated catheter into the bladder. The result in that event is death by acute suppurative peritonitis.

46 Dittrich R. *Deutsche med. Wchnschr.* 48:974 (July 21) 1922.

47 Rost F. *München med. Wchnschr.* 64:5 (Jan. 2) 1917.



chest, but no gastro-intestinal symptoms. She was most comfortable in a half sitting position, which reduced her cough to a minimum.

*Physical Examination*—The patient had evidently been a well developed and healthy woman, but she now appeared tired, drawn, and pallid from the effects of the violent, racking cough which came on at frequent intervals. Nothing abnormal was found except for the chest and upper part of the abdomen. The chest was symmetrical, expansion being equal on both sides, and there was tenderness on pressure over the margins of the right ribs. An area, slightly dull on percussion, was made out in the paravertebral region near the base of the right lung. The breath sounds were bronchovesicular at the right apex posteriorly, and from the right interscapular region to the base and outward to the posterior axillary line, there was rather loud bronchial breathing. There was increased vocal and tactile fremitus in this area, and a few medium râles were heard. The anterior parts of the lungs and the left side were clear. There was a linear scar in the right upper quadrant of the abdomen with a small drainage scar adjacent. When the patient coughed or sat up, there was herniation of the wound. The fingers showed linear markings and incurving of some of the nails, but no clubbing of the finger tips.

The temperature on admission was 37° C (98.6° F), pulse rate, 84, respiration, 22 and blood pressure, 104 systolic and 66 diastolic. The red blood count was 3,568,000 and the hemoglobin reading, 82 per cent (Sahl). The blood smear did not show any abnormalities. The blood count revealed 7,700 white blood cells, polymorphonuclears, 76 per cent, lymphocytes, 20 per cent and mononuclears, 4 per cent. The urine was clear with an acid reaction; the specific gravity was 1.020 and albumin and sugar were not present. Microscopically, the urine was normal.

May 4, 1926. About 75 cc. of dark yellow, mucoid, odorless sputum was expectorated the day before. A Gram stain showed a few mixed bacilli. An acid-fast stain did not reveal any tubercle bacilli. The mercuric chloride test was positive for bile.

May 5. Sixty cubic centimeters of yellow sputum was expectorated. The urine contained a slight trace of bile.

May 6. One hundred cubic centimeters of yellow sputum was expectorated that gave a strong nitric acid test for bile. The stool was large and light colored, but gave a positive reaction for bile. The Wassermann test on the blood was negative. Plasma bilirubin was slightly positive in a 1:2 dilution. The results of the phenolsulphonphthalein test for kidney function are given in the following table.

*Phenolsulphonphthalein Test for Kidney Function*

Hours	Total Output, Cc	Phenolsulphonphthalein Percentage
1	460	20
2	100	12
Total	560	32

*Roentgen-Ray Examination*—The roentgen-ray examination performed by Dr. S. L. Warren on May 3 and 4 showed that the excursion of the left side of the diaphragm was increased, and the costophrenic angle was clear and sharp. The left lung transmitted the rays more brilliantly than usual in the apex and upper lobe so that the larger bronchi were easily visible. The region of the left hilum had increased considerably in density and a marked amount of peri-

the trauma, which was most typically illustrated by case 1. Apparently a slight force is sufficient to rupture a distended bladder in a patient under the influence of alcohol. This was emphasized long ago by Bartels,<sup>40</sup> who not only mentioned that the beverage tended to fill the bladder with urine, but also said that it even tended to weaken its musculature, so that it was less resistant to slight stress. In addition the anesthetic action of the alcohol would probably render the abdomen insensitive to irritation and delay the onset of typical symptoms. For this reason many patients would probably delay seeking medical attention.

All the cases displayed the signs of abdominal distress which would naturally follow the introduction of a slightly irritative fluid in large quantities into the abdominal cavity. The inability to void urine was noted in two cases, and the yield of a small amount of blood on catheterization was noted in one. These signs are given great prominence in the literature as important indications of a vesical perforation.

The escape of urine into the abdomen apparently is not so serious as the escape of intestinal contents. Patient 3 was operated on about one and one-half days after trauma and went on to final recovery. The urine seemed to cause, at the most, only a slight irritation of the peritoneal surface. However, the most advisable course after rupture of the bladder is an immediate laparotomy and repair of the perforation, whether it is intraperitoneal or extraperitoneal. The continued extravasation of urine may lead to complications which are apt to prove fatal.

#### SUMMARY

The hollow abdominal viscera comprise the gastro-intestinal tract plus its mesentery and the urinary bladder. They are located mainly in the lower portion of the abdomen, where they are more or less exposed to trauma. They can be readily ruptured by a moderate force applied to the anterior abdominal wall, so that in many instances they may display few symptoms immediately after the injury.

The usual complications which develop after the trauma are hemorrhage into the abdomen, usually from a torn mesentery, or a peritonitis of varying grade from the extravasation of urine or intestinal contents into the peritoneal sac.

The only method of cure in these cases is by operation. Any injury of a hollow viscus, if capable of admitting its contents into the abdominal cavity, must be taken seriously, and the lesion should be repaired as soon as possible. Intestinal ruptures, especially, are more virulent than ruptures of the urinary bladder, because the contents of the former are more infective. Early operation, in any event, offers the only chance of recovery.

<sup>40</sup> Bartels, M. *Arch. intern. Chir.* 22: 715, 1878.

studied on May 14 and it was found that the total amount of blood chlorides was 0.469 mg per hundred cubic centimeters, the carbon dioxide combining power, 54.5 per cent, and the nonprotein nitrogen, 26.6 mg per hundred cubic centimeters.

The second operation, performed under nitrous oxide, consisted in removing the drains, introducing the hand over the dome of the liver, breaking through into an abscess cavity which discharged a large amount of foul smelling colon bacillus pus and reintroducing three drains.

The prognosis appeared grave, but the operation itself caused little disturbance in the patient's condition. She was given physiologic sodium chloride solution by hypodermoclysis and a transfusion of blood following the operation.

Cultures of the pus obtained at operation grew *B. coli-communis* and *Staphylococcus aureus*.

Improvement began with the cessation of vomiting and continued steadily with a free drainage from the wound and a gradual diminution in the cough and the amount of sputum. The sputum still showed a trace of bile by Heller's nitric acid test one week after the operation, and *Bacillus coli* was grown from the sputum on the same date. There was a sudden change for the worse on May 22 with a rise in temperature to 40 C (104 F), the pulse rate went up to 140 and the respiration to 40. There was a chill, marked dyspnea and cyanosis, restlessness, a cold clammy perspiration and a drop in blood pressure to 72 systolic and 49 diastolic. The percussion note over the right side of the chest was tympanitic; the breath sounds were absent, there was little movement of the right side of the thorax. The heart was displaced far toward the left axilla, and the breath sounds on the right were exaggerated. The white blood count was 23,000. It was evident that there was a pneumothorax, this was confirmed by a bedside roentgenogram.

Aspiration of about 800 cc of air from the right pleural cavity resulted in an almost miraculous change in the general condition and immediate relief from all distressing symptoms. We do not understand the mechanism of this pneumothorax. If the perforation occurred beside the fistula through the diaphragm, it is difficult to understand why infection of the pleural space did not occur. Wherever the perforation was, it was sealed off immediately, as the pneumothorax did not recur following one aspiration of air. From this time on, the patient improved rapidly, so that the drainage had practically ceased by May 30, and the cough was almost gone. A furuncle on the right thigh was the only other complication during convalescence.

On June 19, she was discharged from the hospital with a small area of granulations at the site of the incision; there was no pain or evidence of inflammation in the region. An occasional dry cough occurred without sputum, and the patient seemed to be in fairly good general condition. The thorax looked symmetrical, the respiratory movements were good. The percussion note was resonant, posteriorly and anteriorly, but impaired at the base of the right side of the thorax, both laterally and in the back. The right base was percussed out from about 2 to 3 cm higher than the left, and the lung did not descend as much here as on the left. The breath sounds were distant with a slight bronchovesicular quality, but râles were not heard. The edge of the liver was not painful on palpation.

On July 9, 1926, the patient reported for examination with her wound closed and without complaints except that rarely, she had a dry cough, never accompanied by sputum, and residual weakness resulting from her long confinement in

Obviously, the age at onset is difficult to determine because in a majority of cases the deformity was discovered accidentally at a time when it was well developed and it was impossible to estimate how long it had been present. In the case of girls, scoliosis is often first noticed by the dressmaker, or when examination of the back is made following some minor injury. In a fairly large proportion of our cases the spinal deformity was discovered during a routine examination by the family physician or during examination at school or at a scout camp. This is gratifying, as it indicates that the medical profession as a whole is becoming informed of the importance of the condition and is realizing that the child will not outgrow the deformity and is insisting on proper and efficient treatment.

#### SYMPTOMS

The symptoms vary somewhat with the etiology. They are mild at onset, and often the deformity is the only complaint. This however is usually progressive. In the idiopathic group the children are often tall and slender, slightly undernourished and growing rapidly. They may complain of tiring easily on exertion and of having a dull backache which is at times referred to the pelvic or shoulder girdle. There may be awkwardness in walking, shortness of breath and nervousness. Cardiac irregularity and tachycardia were noted in a few cases.

#### ETIOLOGY

The etiology of scoliosis, especially of the static or idiopathic variety is obscure. According to Lovett<sup>1</sup> it originates in the flexed position of the spine, and the immediate cause is some asymmetry of development or posture which leads to the superincumbent weight of the upper part of the body being borne in an oblique direction on an unstable spine, thus causing it to deviate from the midline. Any faulty attitude habitually assumed by the growing child will result in uneven distribution of the weight and is the direct cause of the deformity.

The predisposing factors are varied and many theories have been suggested. For example (1) It has been claimed that all cases are due to unrecognized anterior poliomyelitis which may have involved only the spinal muscles. (2) Redard<sup>2</sup> suggested the large incidence of flatfoot coincident with scoliosis as an etiologic factor. As will be shown later this does not hold true in our series. (3) Brackett<sup>3</sup> studied

1 Lovett, Robert W. The Mechanics of Lateral Curvature of the Spine. *Tr. Am. Orthop. A.* **13** 251 1900.

2 Redard, P. De la scoliose dans ses rapports avec le pied plat. *Tr. Am. Orthop. A.* **9** 339 1891.

3 Brackett, F. G. An Etiological Factor in Lateral Curvature. *Tr. Am. Orthop. A.* **9** 207 1890.

Besides the foregoing conditions, we have been able to find in the literature reports of only forty-nine really authentic bronchobiliary fistulas that fit our definition

The majority of these fistulas were caused by suppurative processes affecting the subphrenic space, liver, gallbladder and biliary passages. Suppuration followed biliary tract disease, cholelithiasis or cholecystitis—in at least twenty-two instances, verified by operation or autopsy—and probably it was the primary cause in thirteen other cases not proved. These patients either recovered spontaneously or postmortem examination was not performed. In some cases, more than one cause operated with the suppurative process to produce the fistula. Eschenhagen<sup>21</sup> reported such a case in which there was a stone in the common duct and a tuberculous process which spread along the fistula from a tuberculous cavity in the apex of the right lung. Ido and Yasuda<sup>7</sup> and MacDonald<sup>22</sup> reported cases of biliary tract disease and syphilis as possible etiologic factors. In MacDonald's case, antisyphilitic treatment caused the bile to flow in the normal manner, and thus closed the bronchial fistula. This was probably due to the resolution of a gumma which was blocking the common duct. The diagnosis of biliary tract disease was made only when the patient coughed up some calculi at a later date. Association of biliary tract disease with echinococcus cyst of the liver was noted by Klauber,<sup>23</sup> Sendler<sup>9</sup> and van Wijhe and Hammer<sup>24</sup>. In Klauber's case, the echinococcus cyst was discovered at a second operation after biliary disease had been proved at an operation two years previously. The same sequence held for Sendler's case, but in van Wijhe and Hammer's case the order was reversed, the echinococcus disease preceding the gallstones by several years and perhaps having no relation to the bronchobiliary fistula.

Oetiker<sup>25</sup> reported a most unusual bronchobiliary fistula due to cancer at the head of the pancreas and tuberculosis of the liver and biliary passages.

Bruhl and Lyon-Caen<sup>26</sup> recorded a case due to syphilis—the breaking down of gummatous tissue with the establishment of a fistula.

Lebert<sup>13</sup> found ascaris worms blocking the main bile ducts and causing abscesses of the liver and a fistula. Lobstein's<sup>27</sup> case, which

21 Eschenhagen *Deutsche med Wchnschr* **28** 538, 1902

22 MacDonald, G C *Lancet* **2** 973, 1890

23 Klauber, O *Arch f klin Chir* **82** 486, 1907, *ibid* **91** 364, 1910

24 Van Wijhe, S J, and Hammer, E *Nederl Tidschr v Geneesk* **67** 771

1923

25 Oetiker, L *Schweiz med Wchnschr* **56** 501, 1926

26 Bruhl, M J, and Lyon-Caen, M L *Bull et mem Soc med d hop de Paris*, 1909, p 295

27 Lobstein, quoted by Ollani *Complém du dict d sc med*, vol 34

## TYPES OF SCOLIOSIS

*Idiopathic Scoliosis*—The static or idiopathic group was by far the largest, comprising seventy-nine cases, or 61 per cent of the total number. There was also a greater relative frequency in young girls in this group. While approximately 70 per cent of the total series of 125 cases occurred in females, sixty-three of the seventy-nine cases in the idiopathic group or about 80 per cent, were females. The average age at which the deformity was noticed was 13 years, and the average age at the time of the examination was 15 years. In all cases the chief symptom was the deformity.

The diagnosis of idiopathic scoliosis can be made only by exclusion as there is nothing characteristic either in the type or in the severity of the spinal deformity. The scoliosis varied from mild to extreme curvatures in all regions of the spine, both total and S-shaped curves being found. The typical deformity seen in adolescent girls is however a moderately advanced curve in the dorsolumbar region, with compensatory curves above or below.

As a rule, this group responds more favorably to treatment than the other groups, the curvature being easier to correct and to maintain corrected.

*Paralytic Scoliosis*—Twenty-five cases were caused by anterior poliomyelitis. Of this group, sixteen occurred in females and nine in males. The average age at which the patient was examined was 15 years. Practically all gave a definite history of onset with paralysis, and the examination revealed muscular weakness, atrophy and the characteristic deformities of the extremities. In a previous study of anterior poliomyelitis, I<sup>7</sup> found scoliosis in 30 per cent of old cases. The deformity in paralytic scoliosis is often extreme, and is usually a total curve or one large curve and a small compensatory curve. Pain is a frequent symptom, being caused by impingement of the ribs on one another or on the pelvis. The deformity in advanced cases is difficult to correct or to maintain in even the slightest correction.

*Congenital Scoliosis*—There are ten cases of congenital scoliosis in the series. As previously mentioned only the gross malformations are included; other cases which show congenital anomalies being classed in accordance with the predominating etiologic factor. All cases showing anomalous conditions of development however are charted in the table and will be included in this discussion. As shown in the table thirty-three cases or 26 per cent of the total number have developmental anomalies. Adams stated that on routine roentgen-ray examination anomalies of the spine are found in about fifteen or 16 per cent of

<sup>7</sup> Mitchell, Joseph I. The Residual Paralysis and Deformity of Anterior Poliomyelitis. J. Bone & Joint Surg. 7: 619, 1925.

have been present. The bronchial tree generally shows surprisingly little reaction to the bile which passes through it. The bile itself may be heavily infected or almost sterile, depending on the underlying pathologic process.

The most common localization for a bronchobiliary fistula is through the dome of the diaphragm over the uppermost part of the convexity of the right lobe of the liver. The portion of the lung involved depends entirely on the localization of the process below the diaphragm, and although it is usually posterior or lateral, it may be anterior in cases in which the gallbladder itself is adherent to the diaphragm (Mandard)<sup>12</sup>. In Burgess'<sup>34</sup> case there was a remarkable variation as the fistula extended from the left lobe of the liver to the lower part of the left lung. Purulent collections may take extraordinary courses in trying to reach the exterior (Cayley,<sup>2</sup> abscess of the left lobe of the liver to the left pleural cavity, Legg,<sup>3</sup> through the diaphragm into the pericardium and the pleura, and Simmons,<sup>35</sup> in the liver, through the diaphragm into the middle mediastinum and then to the right bronchus).

The reaction in the tissues about the fistula is the same as that of any chronic suppurative process. There is always an infiltration with fibrous tissue and round cells, in addition to the products of acute inflammation when it still exists. The liver cells about the fistula show atrophy, and interstitial proliferation of connective tissue is prominent. The lung tissue near the fistula may show a catarrhal or purulent pneumonia (Schultze),<sup>36</sup> (Scevos Zervos),<sup>37</sup> edema (Dreschfeld)<sup>38</sup> or even a gangrene under some circumstances (Tuckwell),<sup>39</sup> but the acute process usually subsides with the drainage through the bronchus, leaving only a fibrous reaction about the fistula. When the process becomes chronic, there is little likelihood of an acute pulmonary flare-up.

Occasionally a cavity exists in the pulmonary tissue (Luzatto,<sup>40</sup> Mandard),<sup>12</sup> sometimes multiple cavities (Schultze)<sup>36</sup> or multiple abscesses (Schlesinger)<sup>41</sup>.

#### SYMPTOMS AND SIGNS

Bronchobiliary fistulas give a clearcut picture which is unlike that of any disease process.

In the course of an illness pointing to the right upper quadrant of the abdomen or to the base of the right lung, a sudden critical change

34 Burgess, A. H. *Brit J S* **9** 253, 1921.

35 Simmons, D. B. *Am J M Sc* **74** 463, 1877.

36 Schultze, F. *Virchows Arch f path Anat* **61** 131, 1874.

37 Scevos Zervos. *München med Wchnschr* **48** 147, 1901.

38 Dreschfeld, J. *Lancet* **2** 867, 1879.

39 Tuckwell, H. M. *Tr Path Soc, London* **21** 223, 1870.

40 Luzatto, M., quoted by Ollani. *Cong di med intern Roma* **4** 432, 1891.

41 Schlesinger, H. L. *Mitt a d Grenzgeb d Med u Chir* **16** 240, 1906.

CASE 3—A girl, aged 17, presented a severe right dorsal curve. There were thirteen fully developed ribs on the left and fourteen ribs on the right side. There was considerable rotation, with distortion and wedging of the vertebra from the third to the seventh dorsal. There was also a spina bifida of the fifth lumbar vertebra with absence of lamina and articular process on the right.

CASE 4—A youth, aged 19, showed a moderate dorsal scoliosis convex to the right. The fifth and sixth dorsal vertebrae were wedge-shaped, being narrower on the left side. The sixth rib on the right was widely separated from the fifth and seventh, and there was a partially developed rib between it and the fifth rib synostosed to the sixth. There were thirteen ribs on each side.

CASE 5—A girl, aged 16, complained of a very short neck and a mild dorsal kyphoscoliosis, convex to the right. The roentgenogram showed a congenital anomaly of the lower cervical spine. One half of the body of the seventh cervical vertebra was absent and a well developed rib was articulated on the left.

CASE 6—A youth, aged 19, was examined for an S-shaped curve convex to the right in the cervicodorsal region, convex to the left in the upper dorsal and convex to the right in the middorsal region. On roentgen-ray examination thirteen ribs were demonstrated on the right side, the last one being rudimentary. The left half of the first dorsal vertebra and the first rib were absent. The eleventh rib was absent, thus making eleven ribs on the left. The lumbosacral joint was asymmetrical. Figure 1 shows the roentgenogram of the spine.

CASE 7—A girl, aged 1 year and 3 months, had a right dorsal curve at birth. The roentgenogram revealed absence of the left half of the seventh and eighth dorsal vertebrae and of the seventh and eighth ribs. The sixth and ninth vertebrae were wedge-shaped.

CASE 8—A girl, aged 13, presented a dorsolumbar scoliosis convex to the right. There was a congenital malformation of the fifth lumbar vertebra and the lumbosacral articulation.

CASE 9—A boy, aged 10, had a right lumbar curve with anomalous development of the lumbosacral joint.

CASE 10—A boy, aged 10, presented a right dorsal scoliosis. The left leg was shorter than the right, and the left foot was clubbed. The eighth, ninth, tenth and eleventh dorsal vertebrae were wedge-shaped, being narrower on the left and anteriorly than on the right and posteriorly. There were thirteen fully developed ribs on each side and a small fourteenth rib on the left. The extra rib articulated with the first lumbar vertebra.

*Etiology*—Four cases were caused by empyema, three in boys and one in a girl. There was a history of pneumonia and empyema in early childhood followed by collapse of the lung. The deformity in this group may be great and is resistant to treatment because the collapsed lung cannot be made to expand the wall of the chest.

*Associated Conditions*—Various associated conditions were noted, some of which were dependent on the same etiologic factor as the scoliosis and none of which should be considered as etiologic factors in themselves because the relative frequency of each is small in comparison with the total number of cases.

The first to be considered is inequality in length of the legs. In only ten cases, excluding the paralytic group, was there a difference



before bile came up, and it never came up without coughing" Schlesinger's<sup>41</sup> patient brought up "only a little with great effort" On the other hand, there was a welling up almost without effort in the cases of Dreschfeld,<sup>38</sup> Klauber,<sup>23</sup> Laboulbène,<sup>32</sup> Roper<sup>42</sup> and Smith and Rigby<sup>40</sup> Dmitrenko,<sup>31</sup> furthermore, claimed that "at night during sleep fluid comes out without the patient's knowledge" In MacDonald's<sup>22</sup> case, "the fluid came easily when he leaned forward", and Olan<sup>8</sup> said that "stooping down especially causes expectoration"

Once the fistula is established, the course is variable Some fistulas remain open permanently, with a continuous discharge of bile through the bronchial tree This usually indicates a complete block of one of the main ducts below Mayo-Robson<sup>48</sup> recorded a case in which one of the hepatic ducts was blocked and in which there had been a steady expectoration of bile for nine years A considerable number of instances of continuous expectoration over a period from two to six months are recorded Other fistulas open and close in repeated attacks A typical example is the patient of Ido and Yasuda<sup>7</sup> who had recurring attacks of one to two weeks' duration at least four times Graham's<sup>6</sup> patient had an attack lasting sixteen days, he had a free interval of four months, and then a second attack of four to five days followed by a free interval of ten years before the fistula again opened for a long period There are a good many reports of one attack succeeded by a free time and then a recurrence Eichler<sup>49</sup> recorded a case in which the patient was free from trouble for twenty years between attacks

The character of the expectoration often undergoes a cycle of change from a thick, purulent green, brown or yellow to a clearer liquid yellow or green, and finally to a thin, white mucoid type (Schultze,<sup>30</sup> Sendler,<sup>9</sup> Vissering<sup>50</sup>)

The amount of sputum expectorated daily varies from 50 cc to over a liter The average patient, however, does not maintain a constant level of expectoration, variations of from 100 to 200 cc daily being frequent In the average well established case, the patient coughs up at least 500 cc daily Tyrman's<sup>28</sup> and Nermord's<sup>51</sup> patients expectorated 1,200 cc on one day and Oetiker's<sup>25</sup> patient, 1,100 cc Roper's<sup>42</sup> patient averaged from 1 to 1½ pints (473.18 to 709.76 cc) over nine years The quantity raised with one coughing spell varies from 5 to 10 cc Graham's<sup>6</sup> first patient coughed up "a large tablespoonful" at each bout of coughing Perrier's<sup>45</sup> patient coughed up "small mouthfuls" of material

48 Mayo-Robson, A W Practitioner **75** 12, 1905

49 Eichler, F Berl klin Wchnschr (Ewald Festnumm) 1905, p 97, Mitt  
a d Grenzgeb d Med u Chir **16** 551, 1906

50 Vissering, E Munchen med Wchnschr **43** 567, 1896

51 Nermord, H These de Paris, no 239, 1891

shoulders and increased lumbar lordosis were observed in a small percentage of cases. Four cases in the series showed evidence on roentgen-ray examination of a disturbance of the epiphyseal areas of the vertebrae suggesting an osteochondritis or epiphysitis. As mentioned previously there was muscular weakness, atrophy and deformities in the paralytic group, and skeletal malformations in the congenital cases. One case showed torticollis, one a supernumerary thumb, and one a talipes equinovarus of congenital origin. Twenty-two cases showed albuminuria.

#### TREATMENT

With the introduction of ankylosing operations on the spine, interest in the treatment of scoliosis has been greatly stimulated. Fusion of the affected region of the spine offers a practical and efficient method of preventing the increase of the deformity, and when combined with thorough preoperative correction gives a more definite goal toward which both patient and surgeon may strive, than can be anticipated in the majority of cases in which other methods of treatment are used.

As previously mentioned, our study of treatment is confined to thirty-six cases. These patients are unselected, except for the fact that they have cooperated sufficiently well in treatment and have returned for observation to enable us to determine something of the effect of treatment and the permanency of the results. Ten of these cases have been fused.

*Corrective Treatment*—We have endeavored to adapt the treatment to the individual requirements of the various patients. In some cases two or more methods have been employed and in many cases several casts have been applied successively before a satisfactory degree of correction has been secured. The standard of maximum correction must be determined not only from the external contour but also by the roentgenogram. However, one must often be satisfied with a good cosmetic result. The duration of the corrective period usually varies from eight to twelve weeks but in a few cases has been as long as eighteen months.

Traction on a convex stretcher frame, as advocated by Whitman, was used on six patients, four of whom were later operated on. It has been found effective especially in the paralytic cases in extending the spine, lessening the angular deformity of the ribs and expanding the chest on the contracted side.

Most satisfactory results have been obtained in suitable cases with the turnbuckle cast described by Lovett and Brewster.<sup>10</sup> It is as follows:

<sup>9</sup> Whitman, Royal. Observations on the Operative Treatment of Scoliosis. *J. Orthop. Surg.* 3:350, 1921.

<sup>10</sup> Lovett, R. W., and Brewster, A. H. The Treatment of Scoliosis by a Different Method from that Usually Employed. *J. Bone and Joint Surg.* 6:57, 1924.

over a very small area—chronic bronchitis. Signs of a cavity are sometimes made out, but more frequently they are masked by the position. The dulness of the liver usually is increased, and the liver may be sensitive on pressure, occasionally a friction rub can be made out. In some cases the signs of subphrenic abscess are present.

#### DIAGNOSIS

The constant presence of bile in the sputum is sufficient to establish a diagnosis of bronchobiliary fistula. Graham<sup>56</sup> said that the expectoration might be bile-stained in jaundiced patients who developed either bronchitis or pneumonia, but that the amount and purity of the bile in a fistula makes the diagnosis certain.

It is important, however, to try to determine the etiologic factor responsible. Amebic abscess usually develops after exposure in the tropics. A period of dysentery with chills, fever and sweating and a painfully enlarged liver follow. The material expectorated is brick red and should be examined for amebas—on a warm stage, and by animal inoculation (kittens). Emetine acts as a specific. Instances of amebic abscess of the liver without preceding dysentery are not rare.

Echinococcus should be suspected in Greeks, Albanians, Italians and Spaniards, and in all people in a subtropical or tropical environment who have been in contact with sheep and sheep dogs. Additional aid is given when eosinophilia or an urticarial reaction follows rupture of a cyst. Positive complement fixation will clinch the diagnosis when an antigen is available. The sputum should be searched for hooklets or portions of walls of the cyst.

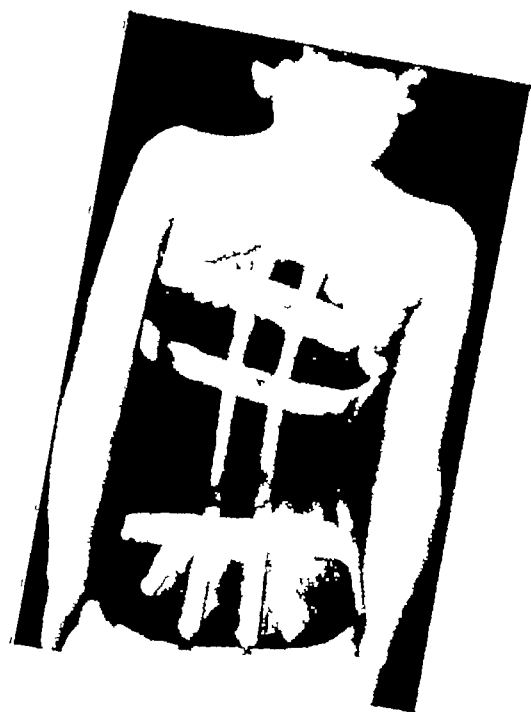
Most other cases give a typical picture of hepatic colic and may be classified as diseases in the liver or bile passages. It is important to know whether the common duct is obstructed completely or whether it is free. This is determined by examination of the stools for bile. The finding of gallstones in the stool is a decided aid in diagnosis (Felix,<sup>56</sup> Gaston<sup>57</sup>).

Roentgen-ray examination may give a great deal of information, especially if it is combined with the tetra-iodophenolphthalein test. The position of the fistula may sometimes be made out by anteroposterior and lateral fluoroscopy. Escudero, Terrada and Gallino<sup>58</sup> used iodized oil 40 per cent successfully by injecting 10 cc. into abscesses of the liver associated with bronchobiliary fistulas. They reproduced some excellent roentgenograms to show the outline of the abscess and the fistula, dif-

56 Felix. Cor-Bi f. Schweiz. Aertze. **33** 250, 1903.

57 Gaston, J. McF. Brit. M. J. **1** 325, 1885.

58 Escudero, P., Terrada, H. M., and Gallino, M. M. Rev. de la Soc. de Med. Int. **1** 563, 1925.



patient's resistance and to plan accordingly. Every case of broncho-biliary fistula offers a different problem, and the decision as to whether the operation should be performed by the abdominal or by the transpleural route depends entirely on the results of the examination. We cannot agree with Smitten<sup>10</sup> that the transpleural approach is the method of choice. The abdominal approach can be carried out under scopolaminemorphine and procaine hydrochloride anesthesia, and one procedure may be all that is necessary.

If the probable block can be ascertained beforehand and the condition warrants it, operation to remove the block (stone in common or hepatic duct, echinococcus cyst or other obstruction) may be all that is needed to cause spontaneous healing of the fistula.

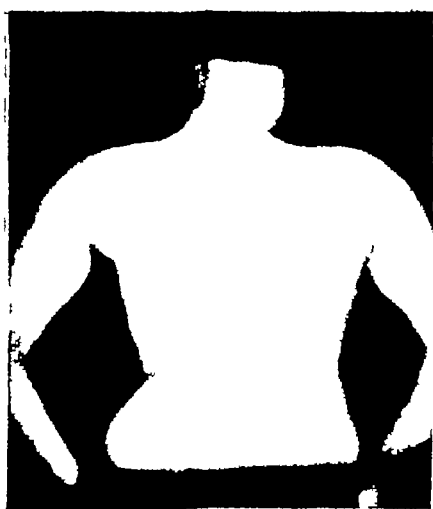
If the condition apparently is dependent on a subphrenic abscess, we advocate the approach by transposing the pleural sac upward. Because the majority of these patients are greatly distressed when they lie down and because they cannot take general anesthesia, we advocate the exposure used in our case. It can be carried out as simply as a transpleural operation with the patient sitting upright and by the use of procaine hydrochloride anesthesia. The advantage is that the uninfected pleural sac can be easily identified and mobilized out of the way, thus safeguarding it from infection. In addition, the patient who is already worn out, is not subjected to the shock of a pneumothorax. The fistula or abscess is approached through the diaphragm, the adhesions to the liver and the diaphragm being gently separated. A whiff of nitrous oxide or ether may be necessary during this manipulation. The adhesions between the diaphragm and liver are a sufficient safeguard against soiling the peritoneal cavity. Drainage is dependent. The danger of secondary pneumothorax must be kept in mind, and suction to the pleural cavity used in case this occurs.

#### CASES REPORTED IN THE LITERATURE

ADAM'S CASE.<sup>43</sup>—A woman, aged 70, had had obstructive jaundice with pain seven years before the case was reported, and a similar attack without jaundice two years before. In January, 1889, more or less persistent obstructive jaundice developed. The pain was never great. Suddenly, on July 13, 1889, a severe persistent pain in the hepatic region and rigor developed and continued the next day. The pain suddenly ceased on the morning of July 15 with the onset of cough and profuse expectoration. Physical examination revealed an exhausted, thin, woman with jaundice, sitting upright and refusing to lie down because if she did, she had a distressing intermittent cough accompanied by expectoration. There was acute bronchitis in the right lung, less marked in the left. The sputum was thick, greenish and yellow with a slight admixture of air. Careful examination showed it to be bile. The temperature was normal. The abdominal examination was unsatisfactory. During the next four days the urine and the conjunctivae became lighter colored, but the stools remained clay-colored. The pain in liver had disappeared. Expectoration of the same fluid continued until the evening of



2



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BRUHL and LYON-CAEN'S CASE<sup>26</sup>—A woman, aged 33, was admitted to the hospital on Nov 20, 1908. She had complained of an increase in the size of her abdomen for six months and expectoration of increasing amounts of yellow-green material of markedly bitter taste. She had had typhoid at the age of 5, scarlatina and syphilis at 19. Eight years before admission she had icterus of two months' duration. In April, 1907, painful crises simulating hepatic colic came on, but although she was subicteric, there was bile in the stools, from this time, she knew she had an enlarged liver. She also had had respiratory trouble and cough for five years. Two years before the case was reported she had marked hemoptysis, and slight hemoptysis had occurred from time to time since then. She lost weight and expectorated habitually. In October, 1908, she expectorated a large quantity of greenish viscous liquid, leaving a prolonged bitter taste and the sensation of having emptied a thoracic collection. A basinful of biliary sputum was expectorated daily in small amounts. Then the quantity of bile progressively diminished, at the end of four days, the sputum was scarcely tinted green. Physical examination revealed a pale, thin patient without fever. The sputum was mucopurulent, with a clear green color. There were no elastic fibers or tubercle bacilli, but large numbers of polymorphonuclears were found. The biliverdin test was positive (Grimbert). The right side of the thorax showed a zone of dulness, continuous dulness of the liver, rough respiration and râles were heard and diminished respiration below. In summary, there were signs of bronchitis without signs of a cavity. The veins about the umbilicus were distended, there was ascites and the liver was very large, hard and irregular, and painless, extending for five to six fingerbreadths below the costal margin. A hard tumor the size of an orange was found in the left lobe, it was not fluctuant, but painful. Icterus was not present. The spleen was enlarged. The stools were almost normal. Eosinophilia did not occur. The echinococcus fixation reaction (Weinberg) was negative. The quantity, nature and color of the sputum varied, sometimes it was mucopurulent, sometimes green. The chest signs also varied, after a large amount of expectoration, the dulness in the right side of the chest diminished. On Dec 23, 1908, a roentgenogram showed two opaque zones, one was posterior to the right side of the chest near the vertebral column, the other anterior to the stomach. On Jan 8, 1909, about 500 Gm of yellow ochre liquid with reddish reflection, recalling fresh bile was expectorated during the night. It had a very bitter taste. On January 30, Gosset performed an exploratory laparotomy. An enormous Spigelian lobe was found, but no pus nor cysts. Death occurred eight days later from hepatic insufficiency. Postmortem examination revealed a large liver, irregular and multilobular. Whitish masses projected from the surface in three different regions, they were hard, not depressible, not fluctuant, and fluid was not found on aspiration. One mass the size of the fist in the region of the right lobe formed the floor of a subphrenic cavity about 6 cm in diameter, the superior wall corresponding to the midportion of the diaphragm, which was perforated at certain points, adherent to lung tissue and sclerosed at others. The walls of this cavity were stained green by bile. There were two other gummas, one was the size of the palm of the hand, and was located on the edge of the left lobe, the other was the size of a nut, and was found on the posterior face of the liver. The right lung was much reduced in size, and its surface was irregular, hard, sclerosed, and intimately adherent to the diaphragm. It was difficult to find a fistula communicating with the bronchus. The condition was probably syphilis of the lung developing simultaneously with gumma of the liver.





rounded, stony hard swelling the size of a golf ball and was densely adherent to the diaphragm above, to the spleen posteriorly and to the left, and to the lesser curvature of the stomach almost to the cardiac orifice. On chiselling through the wall of this swelling, some bile and a quantity of "biliary mud" escaped. The adhesions were freed and the mass removed. An actual opening was not seen through the diaphragm. The common duct was opened and twelve calculi were removed. A probe passed in the left hepatic duct could be felt under the excised area of the left side of the liver. The gallbladder with several small calculi was removed. Recovery was uneventful. The frothy white expectoration steadily diminished and was free from bile for the first ten days. The patient left the hospital one month after operation, free from cough and expectoration.

**CARTER'S CASE<sup>50</sup>**—A woman, aged 70, was in good health except for an occasional "spasm" until two years previously, when she had well marked biliary colic followed by jaundice. Attacks continued at intervals of five or six months. In July, 1888, a severe attack occurred with permanent jaundice and clay-colored stools. One month later, she had an attack resembling bronchitis, in which she daily expectorated about 2 pints (946.3 cc.) of thin, dark green biliary matter. Large moist râles were heard at the base of the right lung. Nothing was felt in the abdomen. Although the expectoration occasionally ceased, it recurred, and the patient gradually wasted and died. Postmortem examination was not performed.

**CATTANI'S CASE<sup>51</sup>** (according to Graham)—A woman, aged 48, who was healthy previously, suffered with pains in the hepatic region and from digestive disturbances, and afterward coughed up bile and pus. Sometimes the tissue of the lung and the liver and striated muscle were found in the expectoration. She suffered from jaundice, and a tumor was noted in the hepatic region. An inflammatory process followed by suppuration began in the liver and extended through the diaphragm into the lung. The patient recovered. The probable cause of the condition was a stone in the common duct.

**COLVIE'S CASE<sup>52</sup>** (according to Graham)—A general in the army who had been in the tropics for some years, suffered with hepatic disease, presumed to be the result of malaria. After having attacks of bronchitis for four years, he was seized with severe pain in hypochondrium, accompanied by fever and vomiting. He commenced to cough up bile after some days and continued to do so for eight months. On several occasions, he coughed up small biliary calculi, which fell into the spittoon with a distinct noise.

**DMITRENKO'S CASE<sup>53</sup>**—On Oct. 8, 1907, a man, aged 50, complained of cough and expectoration of yellow liquid. He became sick three years previously with cough and pains in the left side. At first there was blood in the expectoration, and then it became yellow. One year before the case was reported, there was an increased quantity of yellow sputum. Two months before examination, edema of both legs occurred. Five years before, he had had an ulcer of three weeks' duration on the left leg. Examination revealed poor nutrition, loss of weight and edema of the legs. On respiration, the left side of the chest lagged. The percussion note was higher in pitch on the left above and below the nipple. The breathing below the left scapula was amphoric. Dry râles were heard in the same area and also in the region of the right nipple. A splashing sound was heard in the region of the umbilicus. The patient could not distinguish a bitter taste. His appetite was satisfactory for all kinds of food. There were bulky, uncolored stools daily. The liver was normal in size and position but was not tender. A specimen of urine, 400 cc., was normal. The sputum was tenacious and stringy, it was comprised of 98.2 per cent of water and 1.8 per cent of solids, these solids



occurred followed by profuse hematemesis. The physical signs remained the same. The urine now contained bile coloring matter, but no albumin or blood. Jaundice was not present. On May 7, the patient continued to vomit food, bile and blood. Bronchial expiration, subcrepitant râles and increased vocal resonance were heard in the right suprascapular region. In the right axillary region there were tympanitic percussion, weak vesicular breathing and mucous râles. On May 9, the patient was weaker. The physical signs remained the same, incessant hiccups developed and with every hiccup bile was raised. Twelve ounces (354.8 cc) of sputum was raised in twenty-four hours. On May 13, the patient was much worse, the hiccups and sputum continued and he gradually grew weaker. He died on May 15.

Autopsy revealed the upper surface of the liver and the lower surface of the right lung bound down firmly to the diaphragm by old adhesions. The liver was normal in size and in appearance. The lower surface was traversed by numerous fibrous bands, one of which was stretched tightly across the neck of the gall-

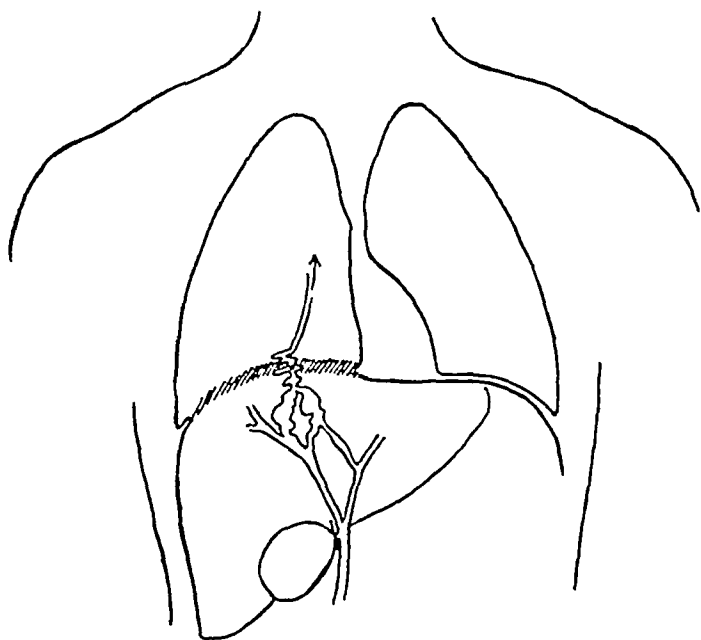


Fig 4 (Dreschfeld's case)—Hydrops of the gallbladder with dilated hepatic ducts, the ducts filled with small stones and infected material, a break through the diaphragm into the bronchus

bladder, obliterating the cystic duct. The gallbladder was dilated and filled with clear mucus without a trace of bile or gallstones. Cross-sections of the bile ducts showed some to be perfectly normal, while others were dilated and filled with thick, creamy, yellow fluid. These were traced to the upper surface of the diaphragm, and were found to be filled with the same material and with small branched calculi. From this cavity, a narrow tortuous canal led into the lung and bronchus. The walls of the fistula were of firm fibrous tissue. The lung about the fistulous tract was edematous and bile stained.

**EICHLER'S CASE**<sup>49</sup>—A patient, aged 43, twenty years previously had been suddenly awakened at night with an irritating cough and expectoration of a thin, fluid, yellow-green sputum. The cough with a greenish expectoration lasted unbroken for a half a year and then ceased. Since the beginning of June, 1905, there had been again a tormenting, irritating cough, with greenish sputum that tasted of bile. A diagnosis of bronchobiliary fistula was made. The patient



bright yellow bile and once or twice with fleshy masses of necrosed liver (proved by microscopic section) continued to be coughed up. Lieut Col H P Hawkins reported from England that the expectoration of bile ceased in the tenth week. The empyema sinus was practically closed at the fourteenth week, and the patient was rapidly becoming well.

ESCHENHAGEN'S CASE<sup>21</sup>—A woman, aged 35, was admitted to the hospital on Sept 10, 1901. For three years, she had had attacks of cramps on the stomach but they were always of short duration. In July, 1901, a severe attack occurred accompanied by jaundice. Four days before admission, she had a sharp attack with a chill. Examination revealed marked icterus, high fever, diffuse rales over the lung, abdominal distention, the liver sensitive to pressure, with a smooth surface and a firm, lower edge one fingersbreadth above the navel. No tumor was palpable in the region of the gallbladder. The urine contained bilirubin and a trace of albumin. The diagnosis was cholelithiasis complicated by

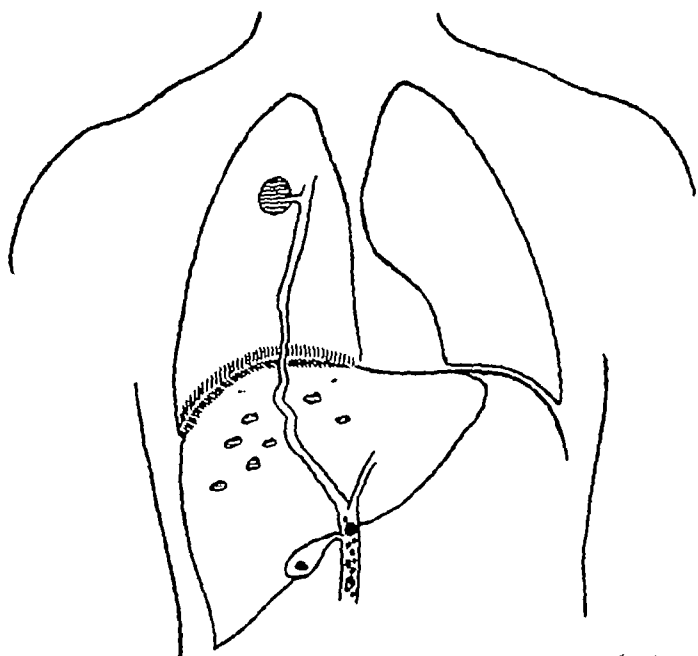


Fig 6 (Eschenhagen's case)—Stones in the common duct with infection, abscess of the liver, fistula through the diaphragm, tuberculous cavity at the right of the apex and retrograde extension of the tubercles in the abdomen.

purulent cholangitis. Operation was considered out of the question because of general septic infection. The liver was not palpable three days later, the dulness diminished, icterus was still intense, and the feces were entirely pale. The patient became comatose. No trace of leukocytes was found in the blood. During the coma there was dulness in the lower part of the right side of the chest posteriorly, and the breathing was bronchial. One week later, the icterus and coma gradually subsided. The dulness of the liver became normal. The liver was no longer tender, but the fever did not subside. Over the lower part of the right lung posteriorly, in a patch about a handbreadth in width was intense dulness, bronchial breathing and loud, ringing rales. The sputum was abundant, slimy and purulent. On Sept 20, 1901, it suddenly took on an offensive foul odor, which lasted five days, then the odor disappeared, but fever and abundant expectoration continued. The infiltration of the lower part of the right side of the chest disappeared gradually, leaving only a diffuse catarrhal condition. Since October 31, the



character from the first, sometimes dark brick red, sometimes yellow and thick, and sometimes green. It had an insupportable odor, even annoying the patient himself. This lasted for about three weeks, on September 10, the sputum became dark green, and was much less odorous and less abundant, the cough was also less frequent. Diarrhea persisted, but from this time, stools suddenly became white. There was no icterus. The child complained of a bitter taste. Toward the end of September, the cough was much diminished, and vomiting and diarrhea had ceased, the stools were still decolorized, but less so than formerly. The patient was thinner, in spite of the return of appetite. He was pale and cachectic, with only the skin left on the bones. There was another attack of diarrhea. The stools were greasy and decolorized. After violent bouts of coughing, he expectorated yellow liquid mixed with aerated mucus. At times this liquid was ejected by vomiting. Signs of general bronchitis were present, consisting of subcrepitant fine and large râles, more over the base of the right lung, especially over the lower two thirds of the chest. There were no signs of tuberculosis. The liver was enlarged and painful. This condition continued for ten days, and then the expectoration suddenly diminished. The bouts of coughing also diminished progressively, and the child recovered his strength with rapidity and took on weight. On Dec. 21, 1879, he left the hospital completely healed, without the recurrence of expectoration of bile. On June 3, 1880, the expectoration had not recurred, and the condition was excellent. There was an epigastric hernia about the scar but no other pathologic condition. This patient showed all the symptoms of a suppurative hepatitis.

**FELIX'S CASE.**<sup>56</sup>—A woman, aged 48, for three years had had short but severe colicky attacks without jaundice. In the middle of January, she had a sudden sickness with high fever and severe pain in the cecal region. This pain diminished when an ice bag was applied over night. Examination showed myoma and a smooth, convex slightly sensitive swelling under the right costal margin (this was mistaken for a kidney). After a few days, she was relatively well but on January 23, she suddenly developed fever of 39.8 C (103.6 F), her pulse became feeble and the rate rapid, she was prostrated, had a severe pain in the abdomen, and marked, foul bleeding from the uterus. The myoma and the surrounding abdominal wall appeared sensitive on pressure, but the region of the liver was not sensitive. Jaundice did not occur. The feces and urine were normal. The condition was thought to be an infection of the myoma with degeneration. On the following night, she had a fit of coughing which lasted five minutes, she raised some sputum, which was the color of the yolk of an egg and was uniform throughout. She complained especially of lack of rest on account of the irritative cough, but still more of the bitter taste of the sputum. Microscopically, the sputum showed pure bile and numerous pus cells. The bleeding from the uterus stopped, the swelling under the right costal margin diminished, the fever decreased and only rarely in the evening did the temperature become as high as 38 C (100.4 F). From January 24 to 28, in spite of treatment with codeine, morphine and other drugs, the cough with biliary sputum persisted with pauses of only from five to fifteen minutes, and prevented sleep. The stools had pigment in them until January 26, but from that time they became completely bleached, not gray, but a zinc white. The bile-free urine was a brick dust red. On January 28 and 29, she had an undisturbed sleep for six hours following the administration of morphine. There was loss of weight in spite of the fact that she ate an ordinary diet. The expectoration remained approximately the same until February 8, amounting to from 150 to 300 Gm daily, at first it consisted of pure bile, but toward the last it was thinned out with bronchial and salivary

bed. She was recovering her strength rapidly and was about to go on a trip to the country to complete her convalescence.

On Oct. 15, 1926, she visited the clinic, having regained her normal health.

*Summary*—A patient with cholelithiasis and cholecystitis was treated by cholecystectomy. Removal of the gallbladder was followed during the immediate postoperative period by what was diagnosed as a subphrenic abscess. An exploration through the original anterior abdominal incision did not reach the abscess and it gradually worked its way through the diaphragm and into the lung, which had become adherent to the diaphragm, and thence into a bronchus. There was no obstruction to the normal discharge of bile, as was demonstrated by the presence of bile in the stools prior to operation, and by the subsequent course of the patient when the discharge of bile to the surface was stopped, there was no evidence of biliary obstruction. We assume that the subphrenic abscess communicated with intrahepatic biliary ducts through an abscess cavity in the sub-

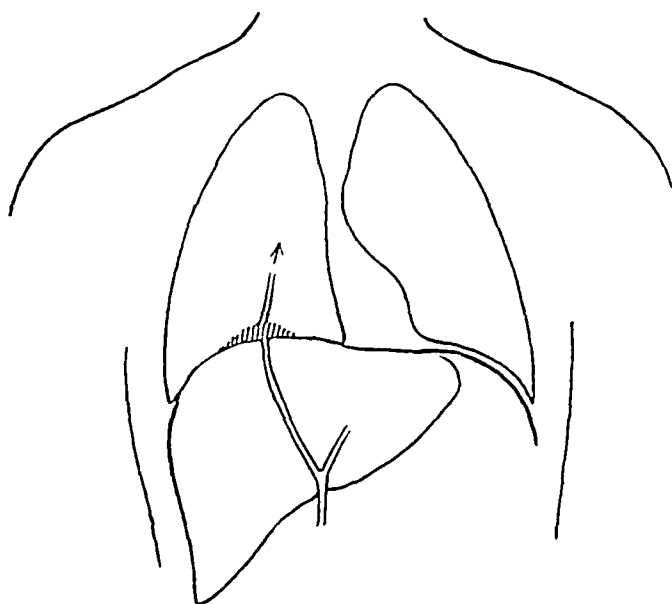


Fig 1 (Morton and Phillip's case) —Subphrenic abscess at the dome of the diaphragm which caused a bronchobiliary fistula by breaking through

stance of the liver. Drainage of this infection with its complicating leakage of bile through the bronchial tree was not sufficient to cause cure. With wide open external drainage, healing and obliteration of the subphrenic and intrahepatic infected cavities was possible. The fistulous tract to the surface, through the diaphragm, lung and bronchial tree closed as fistulas usually do when there is no longer material to be drained through them.

#### ETIOLOGY

Bronchobiliary fistula without doubt is caused more often by echinococcus disease than by any other single agency. Sandler<sup>2</sup> found sixty-eight cases of fistulas due to this cause. Many instances of amebic abscess have also been recorded. Miqiniac said that 17 per cent of tropical abscesses perforate into a bronchus (Smitten).<sup>3</sup>



until 7, when he suddenly vomited about a half pint of pure bile. He coughed constantly all day and passed bile, mucous râles were audible when the ear was applied to the chest, the respiratory murmurs were natural. The pain in the shoulder was not so great as on the previous day, frequent chills occurred during the day, the skin was hot or bathed with perspiration. On May 11, the feces were bilious. The cough and expectoration of bile continued all night. There was a slight diminution of bile in urine. Change did not occur in the skin. The patient had a severe pain in the shoulder during the morning, followed a few hours later by a great flow of bile and mucus, there were signs of a right hemothorax. The patient suffered greatly, not from pain, but from a sense of suffocation and impending dissolution. He was exhausted and his spirits were depressed. On May 12, there were cough and expectoration, the urine was of a more natural color, the skin was not so yellow, there was dullness over the lower part of the right lung posteriorly, the respiratory murmur was indistinct. On May 13, there were less bile and mucus, no appetite, and great debility. On May 14, the cough increased considerably, a pain developed in the shoulder the previous night. On the right side posteriorly, there were bronchial breathing and increased vocal resonance. The urine was natural and the icterus had nearly disappeared. On May 15, the cough and expectoration were diminished, the sweats continued, and the patient hiccupped occasionally. On May 16, the cough and expectoration continued, the mucus was mixed with bile, there was no pus, he had a hiccup and slight pain in the right shoulder. Early in the morning of May 17, after a severe paroxysm of coughing, the right lung suddenly filled with bile and mucus, coughing and expectoration with occasional efforts to vomit continued constantly for two hours, as much as 2 ounces (59.147 cc.) being ejected at one effort, 24 ounces (709.7 cc.) of bile and mucus were ejected during two hours. The hiccups continued. Friction was heard anteriorly over the chest. On May 18, there was little cough and no bile in the expectoration. On May 19, the patient was comfortable, coughing very little, the mucus expectorated was occasionally slightly tinged with bile. There were occasional hiccups. Congestion of the lungs occurred several times during the day. On May 20, the patient was much better. He did not cough. In the afternoon, distressing hiccups developed that lasted all night. On May 21, after a paroxysm of coughing, a sudden gush of bile rushed into lung. There had not been any bile since May 17. A pain developed in the shoulder and the hiccups ceased when bile was coughed up. On May 22, there was no cough or expectoration. On May 23, the patient had a slight pain in the right shoulder. At 3 o'clock in the afternoon after violent attack of coughing, the lung filled with bile, almost a pint of pure bile was coughed up and vomited. The cough and expectoration continued all night. On May 24, the patient was in collapse, he was stimulated, he coughed a little but did not expectorate. On May 25, the patient was free from cough and expectoration. On May 26, pain developed in the right shoulder, a paroxysm of coughing occurred between 11 and 12, more than a pint of bile was coughed up from lung. The cough and expectoration ceased at 5. On May 27, and for several days before, an occasional quantity of healthy pus with matter was expectorated. On May 28, there was an effusion of fluid in the chest. On June 4, the patient's condition improved. On June 21, there was a dullness in the lower part of the right lung posteriorly and a slight uneasiness in the side. There is no record of the case beyond this point, and the ultimate outcome is not known.

FOUCHÉ'S CASE<sup>54</sup> (Gomet's Patient)—A girl, aged 20, was admitted to the hospital on May 18, 1885, with a history of intermittent fever at the age of 2 years, and a light attack of variola at 10 which left no traces. She had always been

was similar, was accompanied by a purulent, not a biliary, sputum, and will not be included

Trauma is the causative factor in some cases. Graham<sup>6</sup> reported one case which followed the kick of a horse, Tyrman,<sup>28</sup> and Elliott and Henry<sup>29</sup> cited cases due to gunshot wounds. In Stumpff's<sup>30</sup> patient, a previous biliary tract disease and diaphragmatic pleurisy were quiescent until the patient was knocked over by a bicycle, after which a broncho-biliary fistula formed.

A definite causative agent could not be assigned to the cases of Dmitrenko,<sup>31</sup> Laboulbène,<sup>32</sup> Smitten,<sup>10</sup> or Yates.<sup>33</sup>

In summary, cases of biliary bronchial fistula are most frequently due to echinococcus disease of the liver and to tropical (amebic) abscess of the liver. Next in frequency follows suppuration due to biliary tract disease—cholelithiasis or cholecystitis—the abscesses forming primarily in the subphrenic space, liver, gallbladder or biliary passages. Suppuration in these situations following any other etiologic factor which acts as a block to the normal outflow of bile may be effective in producing such a fistula. Gumma, cancer, tuberculosis and ascaris worms. Trauma may act as a cause without the necessity of coincident infection taking place. In some instances, a definite etiologic agent cannot be assigned.

#### PATHOLOGY

In the establishment of a fistulous tract from the liver to the bronchi, certain conditions must be fulfilled. There must be a partial or complete interference with the normal bile passages, forcing all or a portion of the bile to seek exit by an unusual channel. Adhesion between the liver and the diaphragm, and the diaphragm and the base of the lung is necessary if the process is to be localized, and not a peritonitis or an empyema. A potential cavity must exist either as an abscess, or as a walled-off space, or as widely dilated biliary or bronchial ducts. It is essential that fairly large bile ducts communicate with this cavity or directly through the fistula with the bronchi. Pressure of the contents of the abscess causes a weak spot in the diaphragm where the muscle fibers become separated and atrophic. The fistulous tract itself may be large or very small, direct or tortuous, but it must consist of firm fibrous tissue which tends to keep the passage patent and prevents it from being closed readily by debris. In almost every case in which a postmortem examination has been made all these conditions

28 Tyrman, J. *Arch f Klin Chir* **89** 434, 1909

29 Elliott, T. R. and Henry, H. G. M. *Brit M J* **1** 9, 1916

30 Stumpff, J. F. *Nederl Tijdschr v Geneesk* **1** 232, 1913

31 Dmitrenko, L. F. *Vruch Gaz* **16** 1 and 29, 1909

32 Laboulbène, A. *L'union med* **20** 271, 1875

33 Yates, A. G. *Brit M J* **2** 1117, 1922

the gallbladder accompanied by fever, but not by jaundice. The pain radiated to the back. He was in bed for three weeks, and the attack lasted for six weeks, but he complained of pain in the hepatic region both before and after attacks. He recovered completely and remained well until the commencement of the present illness. On Nov 27, 1886, he was seized with coughing and pain in the right hypochondrium, 3 inches (7.6 cm) to the right of the median line and a little below the costal margin. Nausea and vomiting also occurred. The vomitus was a greenish-yellow transparent substance and continued for five days till December 2. At that time the pulse rate was 120, the skin was hot and dry. He had a severe chill the night before. On December 3, examination of the chest showed an area of hepatic dullness much increased, and pleuritic friction was heard immediately below the right nipple. The pain here was severe. The patient had an intense headache, the pulse rate was 140, the temperature, 104. He was vomiting freely. The bowels were constipated and the urine was highly

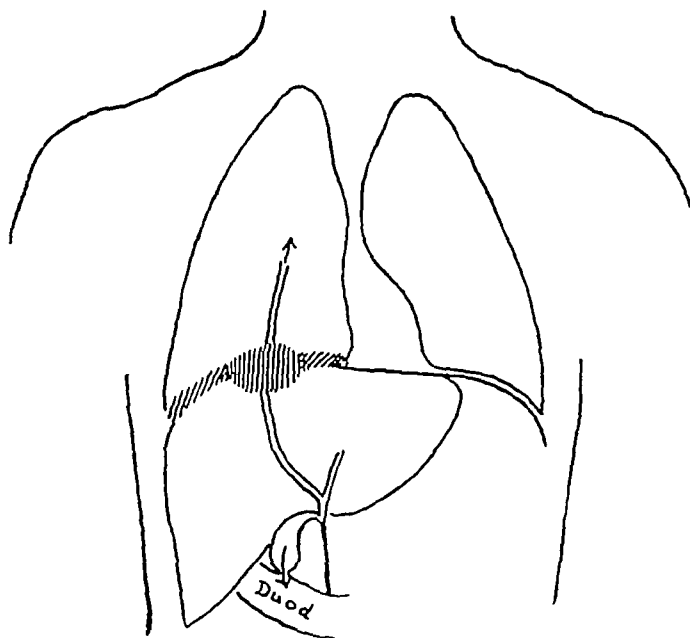


Fig 8 (Gaston's case)—Subphrenic abscess with a break through into the bronchus, obliteration of the common duct, spontaneous cholecystenterostomy

colored. During the evening, he began to cough up bile. On December 4, he coughed up bile freely, and complained of a burning sensation in the right side. He had to cough several times before the bile came up, and the bile was dark green. The temperature was 102 F, and the pulse rate was 100. The pain became less severe and the headache less intense. The condition remained the same until about December 9. At that time, the pulse rate was 108, the temperature 102 and there was slight jaundice. He coughed up bile at short intervals, having two or three attacks of coughing during the hour. He raised a large tablespoonful of bile at each bout of coughing, the bile came only when he coughed, and it amounted to a half a cup full a day. On examination, it was found to be pure bile. The urine also contained a small quantity of bile. The deep liver dullness was on a line below the right nipple in the sixth interspace. A friction sound was heard over the upper surface of the liver anteriorly. Coarse mucous râles were heard over the anterior region of the right side of the chest, the posterior region was normal. The patient gradually improved, the amount

occurs. The condition up to this time has been regarded as hepatic disease of some kind (cholecystitis, cholelithiasis, abscess of the liver, cholangitis, etc.) or diaphragmatic pleurisy or pneumonia (stage of onset). Then a violent persistent pain usually occurs in the hepatic region, accompanied by chills and fever with or without jaundice (stage of blocking of ducts and pressure of accumulation in cavity). After a few days, the intense pain suddenly disappears with the onset of a racking, tormenting fit of coughing and the expectoration of a considerable quantity of bile stained material (stage of breaking through and formation of fistula). Some patients complain a great deal of a sense of oppression and suffocation, and a few of hiccups just before and during the breaking through.

There are a few exceptional cases in which the patient began to cough up bile without indications of previous disease (Burgess,<sup>31</sup> Laboulbène,<sup>32</sup> MacDonald<sup>22</sup>).

In the traumatic cases, there are usually signs of hemothorax or empyema preceding the expectoration of bile.

After the breaking through into the bronchus, the patient suffers with a cough which comes on in "paroxysms," "bouts" or "unbroken fits" and is described as "incessant," "persistent," "troublesome," "tormenting," "irritating," "distressing," "hacking," "racking," "dry" and "hard." In only one case was it considered "very slight and soft" (Roper).<sup>42</sup> The cough is a serious symptom in most cases, giving the patient little rest, either day or night, and leaving him in a state of exhaustion. The patient quickly finds out that position influences the frequency of the coughing fits, and he assumes that position which reduces his cough to a minimum. A half sitting or erect position was assumed in a number of cases to prevent the irritating cough or the sensation of choking (Adam,<sup>43</sup> Dmitrenko,<sup>41</sup> Dreschfeld,<sup>45</sup> Faucon,<sup>44</sup> Graham,<sup>6</sup> Morton and Phillips, Perrier,<sup>45</sup> Roper,<sup>42</sup> Smitten,<sup>40</sup> Smith and Rigby<sup>46</sup>). In Thirloy's<sup>47</sup> patient, the right lateral decubitus was impossible because of pouring out of bile. In Peacock's<sup>12</sup> second case also, the patient could not lie on the right side, whereas in his first case, the patient could not lie on the left side.

Apparently the size and direction of the fistula and the nature of the contents of the cavity influence the ease with which the expectoration is brought up. In Graham's<sup>6</sup> case the patient had to "cough several times

42 Roper, A. C. *Practitioner* 89:718, 1912.

43 Adam, J. *Brit. M. J.* 1:836, 1890.

44 Faucon, V. *J. d. sc. med. de Lille* 2:581, 1880.

45 Perrier, S. *Thèse de Lyon* 1900.

46 Smith, L., and Rigby, H. M. *Brit. M. J.* 2:313, 1903.

47 Thirloy. *Bull. Soc. clin. de Paris* 1888, p. 168.

right pleural cavity Eighteen days after the accident, he began to cough up bile in small amounts after severe attacks of coughing and later he coughed up larger amounts with less effort, but never more than a pint in twenty-four hours, as a rule, less He expectorated mucus and bile On the twenty-sixth day after the accident, the right pleural cavity was aspirated,  $1\frac{1}{2}$  pints of bile stained with serum and pus being obtained An opening was made on the following day and a tube drain was inserted The bile drained for about a week, then seropurulent drainage was maintained for a longer time The expectoration of bile increased after the operation, jaundice did not occur at any time After operation the temperature fell to normal, but it rose again after a week Coincidentally, an increased area of dulness was observed in the hepatic region One pint of bile and mucus was aspirated A second operation was performed on the thirty-third day after the accident, portions of the sixth and seventh ribs being removed, a tube was inserted and mucus and bile were drained After this operation, the stools became colorless for the first time Five weeks later the patient was pale, emaciated and could sit up with difficulty, pulmonary resonance was heard only to the ninth interspace in the right side of the chest posteriorly, anterior superficial resonance was normal to the fourth rib, then there was absolute dulness to the sixth rib, below the sixth rib to the costal margin a tympanitic note was present Two drainage tubes were inserted, when these were removed and the patient coughed, the quantity flowing through both openings was increased, and bubbles of air or gas produced foam The amount of gas which passed through the lower opening was much greater than that which passed through the upper The openings did not communicate (fluid put in one did not come out the other) At various times during the progress, the bile flowed in different channels, through the bronchi, through the pleural cavity and out through the upper opening, into the cavity on the convex surface of the liver and through the lower opening and through the common bile duct The patient suffered severe pain in the right shoulder after the second operation, when the finger was introduced into lower opening The flow of bile increased after  $\frac{1}{4}$  gram (0.015 Gm) of mild mercuric chloride was given every hour for five or six doses Two and a half weeks later, the patient was recovering slowly Bile was found in the bowel The patient coughed up little bilious fluid, and little found its way out through the lower opening

DE HAVILLAND HALL'S CASE.<sup>61</sup>—In 1876, a patient complained of anginal symptoms He had been in good health until 1881, when he suffered from pain in the region of the liver, followed by jaundice Other attacks followed with increase in the jaundice Ultimately he vomited bright colored bile and large quantities of bile stained fluid, subsequently ascertained to come from the lungs The patient made a good recovery, so that the anatomic lesion remained obscure.

HEATON'S CASE.<sup>62</sup>—A middle-aged woman had been ill for three months with chronic hepatitis, and complete dulness over the right side of the chest was found later The right side of the chest measured 2 inches more in circumference than the left She had intense pain, relieved only by large doses of morphine Suddenly she expectorated a large quantity of pus, and in the course of six hours, nearly a chamber full of matter was said to have been expectorated When this large discharge ceased, the expectoration, which continued, was tinged with bile. Great relief from the pain followed the escape of pus, but she was much prostrated When she entered the infirmary, the more marked symptoms had subsided, there was no fever, the pulse was feeble and there were deficient resonance and obscure respiration in the right side of the chest and pain under the axilla She did not remain long in the infirmary, and her further progress is not recorded

MacDonald<sup>22</sup> noted that the expectoration of bile increased from one half to one hour after the taking of food, and Graham<sup>5</sup> observed a similar phenomenon in his second case after doses of  $\frac{1}{4}$  grain (0.015 Gm.) of mild mercuric chloride.

In gross appearance, the expectorated material shows considerable variation. The color may be bright or deep brown, grass green "egg yolk" color or bright yellow or combinations of the foregoing colors. It may be thick and purulent, thin and serous or foamy mucus. There may be a homogeneous appearance or globes of mucus floating in the thin fluid. At times distinct layering is noted when the material stands in a container (Dreschfeld,<sup>38</sup> Schultze,<sup>36</sup> Tyrman<sup>28</sup>).

Occasionally large particles of broken-down tissue, old clots or purulent debris is present. Echinococcus cysts and hooklets have been found frequently. Gallstones rarely are expectorated (Collee,<sup>2</sup> MacDonald,<sup>22</sup> Vissering<sup>50</sup>).

Microscopic examination may show masses of leukocytes, eosinophils, fat droplets, lung and liver cells, elastic fibers, squamous epithelium, fatty acid crystals, hematin crystals, bilirubin and "clumps of destroyed bile in yellow flecks" (Cattani,<sup>53</sup> Eichler,<sup>49</sup> Elliott and Henry,<sup>52</sup> Eschenhagen,<sup>21</sup> Fouché,<sup>54</sup> Ido and Yasuda,<sup>7</sup> Schultze<sup>36</sup>). Search should always be made for pieces of echinococcus cysts or hooklets, amebae, tubercle bacilli and neoplasm cells.

Chemical examination will give a certain diagnosis by any of the well established bile tests (Gmelin, nitric acid, mercuric chloride, Obermayer's reagent [Kapsinow's test]).

The patients often complain of the bitter taste of the sputum, sometimes there is a foul odor as well. The reaction of the material is alkaline, thus distinguishing it from vomitus.

Coincident with the appearance of the biliary expectoration, there may be a diminution and a disappearance of a jaundice. On the other hand, the blocking of the fistula may lead to jaundice and a painful tumor in the region of the liver. The establishment of a spontaneous fistula between the biliary passages and the intestinal tract may cause the spontaneous cure of a bronchobiliary fistula (Kehr). The presence of a block in the common duct can be determined even in the presence of a bronchobiliary fistula by examination of the stools for bile.

Physical signs present in cases of bronchobiliary fistula vary from extensive frank consolidation at the base to a few crackles or rales.

52 Collee, quoted by Graham. *Med. mod. Par.* 1:405, 1887.

53 Cattani, quoted by Graham. *Gr. med. ital.* 45:705, 315 and 325, 1887.

54 Fouché. *Thèse de Paris* no. 338, 1885, p. 32.

55 Kehr, H., quoted by Ohlman. *Chirurgie der Gallenwege*, 1907, p. 111. *Chirurgie*, vol. 8, p. 240.

thorax, and during the day the patient coughed and expectorated from 100 to 150 cc of yellow stained, bitter-tasting, tenacious, slimy, in part seropurulent sputum. Stratification did not occur. Microscopic examination revealed numerous pus cells, few eosinophils and lung epithelium and probable liver cells, but no parasites. The feces were clay colored and foul. Icterus was increased markedly. On the next day the sputum was greenish. On the fifth day, the sputum was deep green, from 200 to 250 cc being expectorated, the cough and bronchitis increased. On the sixth day, the sputum was yellow again, the quantity being somewhat diminished. On the ninth day, the sputum was colorless and a minimum quantity was expectorated. These attacks recurred four times in entirely analogous sequence. The patient was admitted to the hospital on April 29, 1910, on July 19, she suffered with pain in the abdomen, loss of appetite, repeated chills, fever and marked diarrhea. On July 21, she died, after a profuse vomiting of blood. A diagnosis of syphilis of the liver and a fistula between a bronchus and a bile duct was made. Autopsy revealed. The right lung entirely adherent to the wall of the chest and the diaphragm, the lower median part of the lower lobe scarcely being separable from the diaphragm, obliteration of the common and cystic duct, chronic empyema of the gallbladder, fibrous pericholangitis, dilatation of the hepatic ducts and the bronchus, fistula of the hepatic duct to the duodenum, 15 cm below the pyloric ring, and fistula of the hepatic duct to the right lateral bronchus. The bile passage was dilated a fingerbreadth, and had markedly thickened and fibrosed walls. The passage led through to the right side of the liver lappet in a straight direction down into the main branches of the hepatic duct and communicated indirectly with the hepatic fistula to the duodenum. There were universal icterus and anemia.

KEHR'S CASE<sup>55</sup> (according to Oliani)—Symptoms of bronchobiliary fistula disappeared little by little. When laparotomy was performed a shriveled gallbladder was found which communicated with the stomach at the pylorus. According to the author, the bronchial tree fistula healed when this communication formed. It is felt that this is a case of spontaneous healing of a pulmonary fistula through the formation of a fistula between the gallbladder and the pylorus.

KLAUBER'S CASE<sup>52</sup>—A woman, aged 36, had suffered with intense cramps at varying intervals since she was 18, and for twenty-three weeks had been very sick. During this time, she had a severe attack of gallstone colic with pain under both costal margins, radiating to the back, she vomited after meals. The gallbladder was palpable and the liver increased in size. Since the second day of her illness, she had had severe icterus, chills and a temperature as high as 41 C (105.8 F), which subsided after a week, but she still had colic of diminished intensity. The stools were white at first, later they were colored, but a brighter color than normal. The urine was blood red with a brown foam. A careful search did not disclose any stones. There was a family history of tuberculosis. The patient coughed on entering the hospital and fourteen days before entry there was dulness in the right side of the back. On Sept 23, 1906, she coughed up blood. On September 24, a great amount of purulent fetid sputum was expectorated which contained many leukocytes but no tubercle bacilli. This purulent sputum continued until the morning of September 27, when the patient coughed up a green, bitter-tasting fluid. She coughed up during transportation to the hospital a jar full of bile. This was brought up with slight effort. It amounted to a quarter of a liter, and was a foamy, green, thick, ropy fluid which reacted to Gmelin's bile test. The patient could be still scarcely a few moments because of the tormenting cough. She was sleepless at night and exhausted by the cough. The lower half

ferent postural positions being used to bring out the whole relationship Oetiker<sup>55</sup> injected iodized oil from above through the bronchi, but was not able to demonstrate the fistula through the diaphragm

#### PROGNOSIS AND TREATMENT

In some cases, the process is rapid and fulminating, the patient surviving the break through for only a short time. Death in these instances may be due to pneumonia, gangrene of the lung, general sepsis or hepatic insufficiency following prolonged jaundice (Adam,<sup>43</sup> Bristowe,<sup>14</sup> Carter,<sup>59</sup> Gaston,<sup>57</sup> Tuckwell,<sup>30</sup> Weiler<sup>60</sup>)

Other patients progress to a chronic state with continuous discharge of bile over long periods of time. In such cases there must also be some bile emptying into the gastro-intestinal tract, either by free ducts or by spontaneous fistulous openings. Still other patients have recurring attacks with reopening of a closed bronchobiliary fistula, sometimes after a very long closed interval (Graham<sup>6</sup> case one, Eichler<sup>49</sup>). It is unwise to count on the probability of a spontaneous cure when the condition has become chronic, because approximately 50 per cent of such patients ultimately succumb to some complication. There is no doubt on the other hand, that there have been a fair number of cures from expectant treatment alone. The patient in the meantime goes through an agonizing period until the cure is effected by ulceration between the biliary passages and the gastro-intestinal tract or by the expulsion of the obstructing material through the sputum (Cattani,<sup>13</sup> Colver<sup>12</sup> Faucon<sup>41</sup> Felix deHavilland Hall,<sup>61</sup> Kehr,<sup>56</sup> Vissering<sup>9</sup>)

Operative treatment under modern conditions promises relief in a large proportion of cases. There are enough excellent results to warrant advocating operation in all such patients whose condition allows it. (Burgess,<sup>34</sup> Elliott and Henry,<sup>29</sup> Graham<sup>6</sup> case two, Klauber,<sup>20</sup> Korte Mayo-Robson,<sup>48</sup> Morton and Phillips, Roper,<sup>42</sup> Sendler<sup>1</sup> Smith and Rigby,<sup>40</sup> Tyrman,<sup>28</sup> Yates<sup>33</sup>). Equally good results have been obtained in cases of echinococcus. Even patients in a serious condition can be carried through operation in carefully worked out stages. Many operative failures in the past were due to poorly conceived technical procedures and too extensive operation which led to death from shock. It is of the utmost importance to attempt to estimate the probable pathologic process before undertaking any therapy. It is equally important to gauge the

59 Carter, G. Brit M J 1 1119, 1889

60 Weiler, K. Wien klin Wchnschr 15 353 1902

61 Hall, F. deHavilland. Brit M J 2 624 1886. Proc Med Soc Lond 10 69, 1887

62 Korte, quoted by Eichler. Beitr z Chir d Gallen u d Leber 1897, vol 7



KORTE'S CASE 5A<sup>32</sup> (according to Eichler)—A patient, aged 31, had had recurring lumbago, at one time it was accompanied by icterus. On one occasion, she had a cleancut attack of pain in the region of the gallbladder. Three weeks previously, she suddenly coughed up yellow, bitter-tasting pus. On admission, the patient was slightly jaundiced. Over the right lung, there were indefinite diminished breath sounds and sparse râles. Bile stained pus was expectorated abundantly. The diagnosis was abscess of the liver, perforating into the lung, probably caused by gallstones. After operation by the transpleural incision, the wound healed.

LABOULBÈNE'S CASE<sup>32</sup>—A man, aged 46, was admitted to the hospital on March 14, 1875. He always had had good health, had not had syphilis, jaundice or hepatic colic. On Oct 4, 1874, while in perfect health, he took a journey on a train. During the journey, he drank a large amount of beer. On the next day, coughing without great effort, he expelled a green sputum, at the same time, he commenced to notice a disagreeable bitter taste. His tongue was yellow. He had never vomited pus, liquid or membranes. Since October 4, five months in all, the green expectoration had continued, but had never been fetid. His appetite had not diminished. The stools were normal. Coughing prevented him from sleeping at night, and when he did sleep a little, he had bad dreams like those of an alcoholic person. According to the patient, the expectoration was more abundant some time after a meal. Examination revealed a healthy appearing man. Disseminated râles were barely heard in both lungs. Palpation and percussion disclosed hypertrophy of the liver. The sputum was not foamy but was greenish yellow without a foul odor and contained a few bits of unstained mucus. When one listened carefully, one could hear numerous mucus bubbling râles in the middle half of the base of the right lung. Percussion in this part gave a little more obscure note than did the opposite side. While being examined, the patient had a fit of coughing, and expectorated some biliary sputum without great effort. At the same time, the râles almost disappeared. His condition did not change until April 24, then the sputum became small in amount, and there was less bile. Microscopically, there were granular rounded nuclei with yellow pigmentations and a large number of leukocytes. Bloody fluid was present in other parts of the field and very small clots, very rare blood cells and some epithelium of the mouth. There was a gradual diminution in the amount of sputum until no more was raised. The signs at the base of the lungs cleared. The liver was diminished in size. A later note says that the patient had actually been healed.

LEBERT'S CASE<sup>13</sup> (according to Courvoisier and Ohani)—A girl, aged 15, suddenly became ill with chills, high fever, diarrhea, abdominal pain and great prostration. After five weeks, symptoms of pneumonia developed in the lower part of the right lung, followed by pneumothorax. Biliary sputum was expectorated for three months. Death resulted. Postmortem examination revealed numerous ascaris worms in the three large bile passages, and one macerated ascaris in the liver, and an abscess communicating with the bile passages. A large subphrenic abscess had broken through the diaphragm into the right pleura. Pyopneumothorax occurred. There were sieve-like perforations into several bronchi.

LUZATTO'S CASE<sup>40</sup> (according to Ohani)—A woman, aged 58, two years previously had had irregular fever and an intense cough for one month, after which she had expectorated a bitter green-yellow sputum. She became progressively emaciated. Pain developed in the epigastrium and in the hepatic region, death resulted. Autopsy showed a pulmonary cavity in the apex of the right lung. The

July 18 On the morning of July 19, the right lung had become solid. The temperature remained normal. The patient gradually became calmer, more distressed, and more deeply jaundiced and swelling developed in the region of the gallbladder. On July 26, this could be palpated as a sensitive cyst containing fluid. The patient became progressively worse, and died on July 30. Autopsy was performed.

**BRISTOWE'S CASE**—"A woman, aged 32, was admitted to the hospital on April 20, 1852, and died on June 9, 1852. She suffered from intense jaundice and other symptoms of hepatic disease, and shortly before death spat up bile-stained pus. Postmortem examination revealed a deeply jaundiced patient. The left pleura was universally adherent, in the right pleura there were a few adhesions at the posterior part and the base of the lung was firmly attached to the diaphragm. The upper and middle lobes were healthy and crepitant, the lower were useless from collapse, tough, fibrous and slate colored. In the center of the base of the

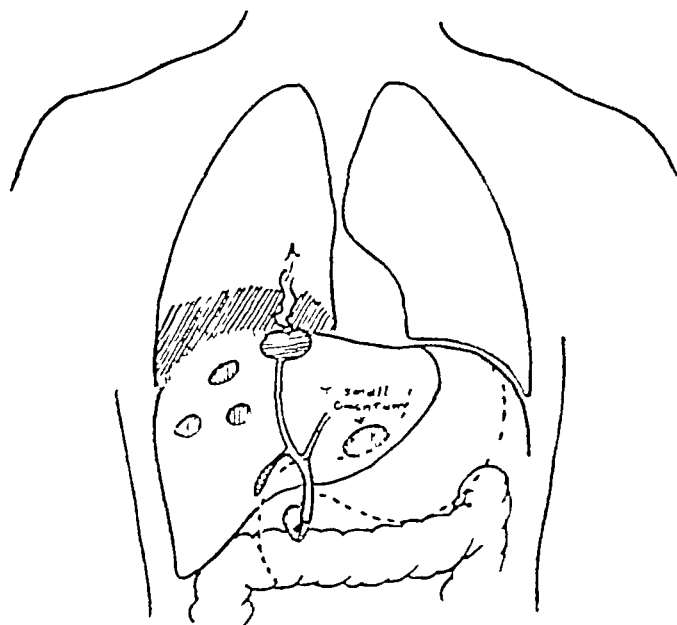


Fig 2 (Bristowe's case)—Collapsed lower lobe of the right lung, liver, and abscesses, one of which opened in the bronchus, common duct of the liver.

right lung was a superficial, eroded and flocculent area of about 2 cm. in diameter, which corresponded to a perforation in the diaphragm and a cavity in the liver. The contents of the bronchial tubes connected with the lower lobe consisted partly of solid matter, and one tube was directly traced to its opening on the external surface. The liver was much enlarged and filled with cavities of varying size, the largest being the size of hen's egg. The largest cavity on the convex surface of the right lobe of the liver communicated with the lung. There was also a large cavity on the under surface of the diaphragm. The cavity on the under surface of the diaphragm communicated with both the diaphragm and the liver. The ulcerated opening the size of the little finger. The common duct was filled by a hard globular, rough stone the size of a large pea. The gallbladder was filled with bile below this in the duct. The gallbladder was small. The common duct ended in a cavity in the omentum. There was also a small cavity in the omentum communicating with the branches of the portal vein.

the base of the lung. The patient became increasingly weaker, and he died in the first part of April, 1850. Autopsy revealed extreme wasting of a normal sized liver with an abscess the size of a thimble, which occupied its anterior edge. There were old peritoneal bands in the region of the liver. The gallbladder was fixed to the diaphragm along the entire extent of its base. It was larger than normal, and the walls were thickened. When opened, it communicated with the thoracic cavity by a rounded opening. The base of the right lung was completely adherent to the diaphragm, the two upper lobes of the lung were healthy, in the lower lobe, there was a cavity having the volume of two walnuts, it was irregular and tortuous and had indurated walls which communicated below with the gallbladder and the apex of which was continuous with a large bronchus by means of distinct opening. In the interior of the sac formed by the gallbladder and this cavity there were numerous calculi—some in the gallbladder, others in the lung—which was bathed in a mixture formed of bile and pus. At the lowest

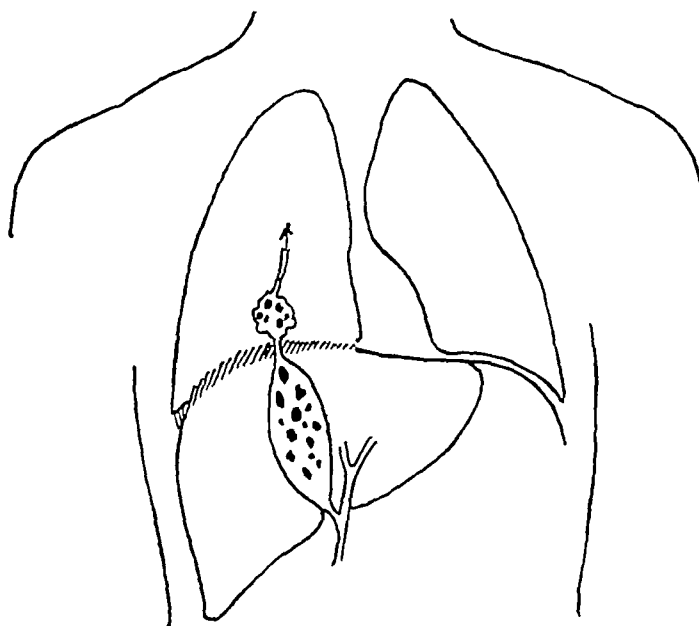


Fig 11 (Manard's case) —Dilated gallbladder full of stones adherent to the diaphragm communicating across the diaphragm with a cavity in the lung which also contains gallstones, this in turn communicates with the bronchus, hour glass type

part there was a type of pus (mud) formed by a large amount of fine gravel, which would have filled a coffee spoon. The canals were intact.

MAYO-ROBSON'S CASE<sup>48</sup>—A man, aged 28, was well until April, 1894, when he had an attack of pneumonia. Six months later, he had an illness accompanied by cough, and on the third day, he began to expectorate. Shortly afterward, he coughed up a large quantity of pus and bile. He had not had any liver symptoms before this attack, except on one occasion when he had pain in the region of the gallbladder. Since that time, he had regularly coughed up bile and pus for a period of nine years. He was thought to have had phthisis, because of the rapid loss of flesh and night sweats. In May, 1903, he was round shouldered and old looking, and his fingers showed marked clubbing. The chest showed diminished breath sounds on the right side to the level of the seventh rib. The liver was decidedly enlarged, but not tender, 3 inches below the costal margin. He was slightly jaundiced. Bile was absent from the feces but it was present in the

*Summary*—The probable course of the condition was as follows: (1) onset eight years before admission, due to gumma of the liver, (2) cough and hemoptysis three years later, and invasion of the lung by gumma, (3) a painful syndrome like hepatic colic and opening of the hepatic canal by gumma and (4) expectoration of bile and formation of a fistula.

**BURGESS'S CASE.**<sup>24</sup>—A woman, aged 59, was admitted to the hospital on Mar. 5, 1921. On Dec. 2, 1920, while walking home from her office she had a sudden attack of coughing and expectorated some thick white phlegm. This occurred frequently during the next three days, and on December 5, she noticed that the expectoration was yellow and had a bitter taste. Except for a few short periods of two or three days each, during which the sputum was white frothy and devoid of any bitterness, she had expectorated daily a frothy yellow fluid varying in quantity from 10 to 20 ounces (295.73 to 590.47 cc). The sputum showed pure bile without pus or blood cells or tubercle bacilli. *B. coli* was present on culture.

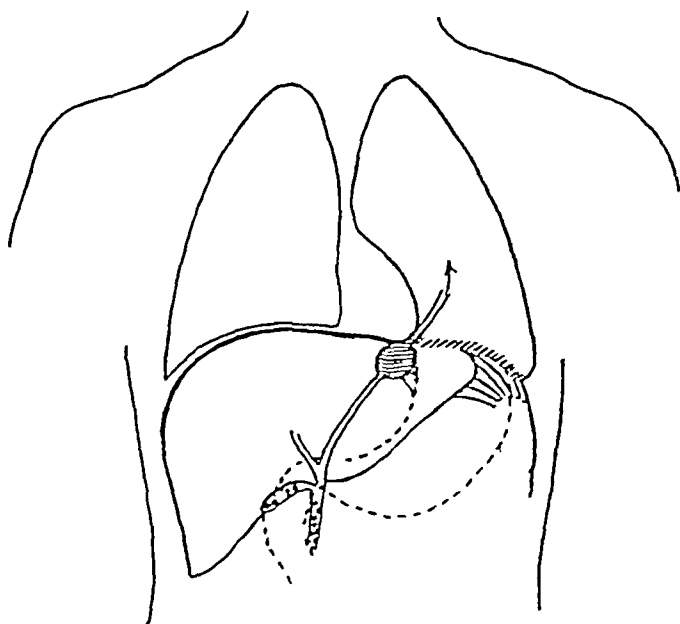


Fig. 3 (Burgess' case).—Gallbladder and common duct full of stones, an abscess cavity in the left lobe of the liver connecting with the left bronchus, with a break through into the left bronchus.

The only previous illness that she could recall occurred about ten or twelve years previously, when she had had a headache and had vomited bile, but this had kept her from work for only a day and a half. Abdominal pain or colic did not occur. At the beginning of her illness she lost considerably, but for the last three months her weight had remained constant. The physical examination was normal. The expectoration varied in color from pale green to bright yellow, was alkaline in reaction and frothy. She coughed up in quantities of 1 drachm (3.69 cc) every ten or fifteen minutes. Frequent coughing allowed her little rest at night. On Mar. 2, 1921, exploratory laparotomy was performed, the gallbladder was found to be thick-walled, and calculi were found in the gallbladder and common duct. The right lobe of the liver was not adherent to the diaphragm, but the left lobe was everywhere adherent as was also the cardiac portion of the stomach. The margin of the left lobe was adherent to the spleen.

decolorized. She retained her appetite, but became thinner. From October to March 13, at 3 p m, she had a chill and attempted to vomit, acute pain developed in the hepatic region. She continued to work, but daily grew weaker and thinner. On March 13, at 3 p m, she had a chill and attempted to vomit, acute pain developed in the hepatic region. The stools became decolorized. She had become increasingly jaundiced for two or three days. On March 14, she was better, the pain had almost disappeared, and her color was commencing to become pale. On March 21, the abdomen, thighs and feet were swelling. She remained in bed until March 30. On April 13, she was very weak, and ascites increased daily. She entered the hospital. Examination showed a very thin jaundiced woman with sunken eyes and a feeble voice. Ascites and dilated veins were present on both sides of the abdomen. The border of the liver was felt one fingerbreadth below the costal margin. During the day and night of April 16, she expectorated frothy, slightly yellowish mucus. On April 18, she coughed up about a basin

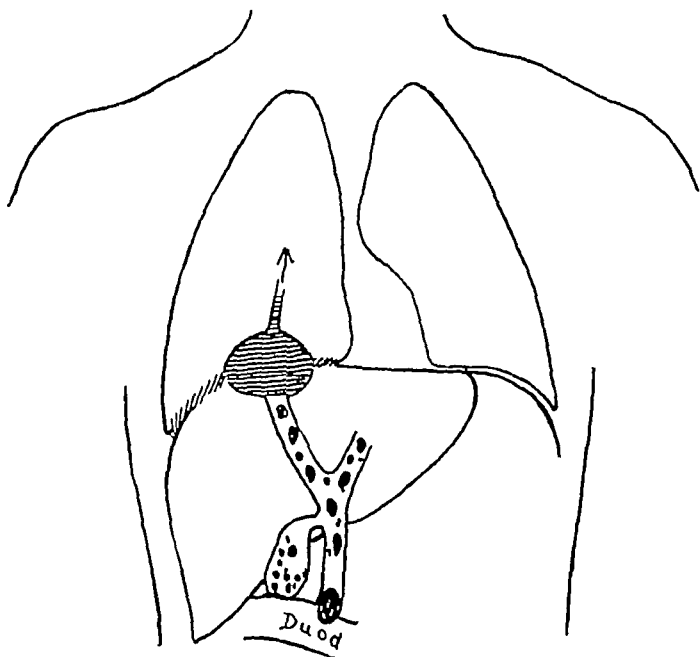


Fig 13 (Nemord's case)—Subphrenic abscess with pulmonary fistula, the bile duct and the gallbladder crammed full of stones

full (1,200 Gm) of greenish, slightly thick liquid with yellow foam, she was sure that it was not vomitus. The stool was without color, there were bile pigments in the urine. Puncture of the liver in the convex border showed only blood. On April 19, she coughed almost all day and night, raising 1,000 Gm of the same type of sputum. Her mouth was dry and there was a bitter taste. There were mucous râles in the lower two thirds of the right lung. On April 20, she had a stubborn cough during the night, thick, green masses of sputum mixed with mucus and some blood, 700 Gm, being expectorated. On April 21, she coughed continuously, but especially in bouts, 300 Gm of sputum being expectorated. On April 23, 300 Gm were expectorated. On April 24, 300 Gm, on April 25, 250 Gm, and on April 26, 250 Gm. The bouts of coughing were less frequent and not so severe. On April 27, she coughed little and there was no expectoration. The abdomen was tapped, 9 liters of slightly greenish non-albuminous liquid being removed. On April 30, the patient passed a bad night. She had fits of coughing, expectorating 200 Gm of liquid bile. On May 2, a



opened, the subserosa was very edematous. Weblike loose adhesions occupied the entire gallbladder, duodenum and region of the diaphragm. After separating the adhesions, a thick mass in the right lobe of the liver and adherent to the diaphragm was palpable. The growth was posterolateral to the summit of the liver, and appeared either as a tumor or a multilocular echinococcus. Retraction of the liver appeared to be too slight for the latter. The liver was somewhat enlarged and showed a round edge. Puncture did not reveal any pus, only cells, at a second puncture brown fluid was found. The examination of the stomach was incomplete on account of adhesions. The region of the pylorus was free but about the head of the pancreas there was a thick, slightly movable resistant mass, which appeared to be a primary cancer. It was not certain that this was the pancreas itself. Cholecystenterostomy was performed. Death occurred the evening after operation from heart failure.

Postmortem examination revealed cancer arising from the head of the pancreas and completely involving the papilla of Vater in the duodenum. The common

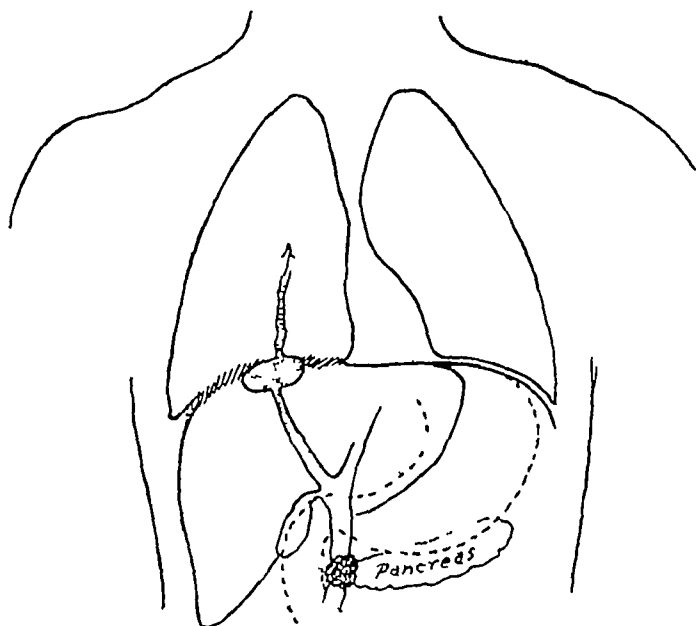


Fig 14 (Oetiker's case) —Cancer of the head of the pancreas with a block of the common duct, tuberculosis at the dome of the liver with a fistula extending through into the lung and bronchi

duct, cystic duct and intrahepatic bile passages were markedly widened. A conglomerate tubercle, the size of a mandarin was found in the liver close to the convex surface. It was hard, showing cheesy decomposition in only one small area. The liver was adherent at this point to the tuberculous diseased diaphragm and the lung. The conglomerate tubercle communicated with the bile passages. The tubercle bedecked fistula led directly from the bile ducts into a widened bronchus. In the lungs there was also a purulent bronchitis, bronchiectasis, old pleural adhesions on the right and a diffuse, thick crop of miliary tubercles somewhat larger than in the lower lobe of the right lung. In the upper lobe of the right lung a small calcified mass was found. Isolated miliary tubercles were found in the liver. The bronchial and mesenteric glands were tuberculous and calcified, the latter group being markedly affected. Cancer metastases were not found. The cancer caused bile stasis, flare-up of tuberculosis, breaking through to the lung. Fresh tubercles in the lung and liver were due to a gland breaking into a vein.

coughed up daily an average of from 700 to 900 cc of almost pure bile. Masses of leukocytes, pieces of lung tissue and elastic fibers were found in the sediment. The urine was entirely free from bile, the stool was light colored but contained hydrobilirubin (sublimite test). An operation was performed to close the fistula but the patient died the day following operation from weakness of the heart and edema of the lungs.

At postmortem examination there was an open fistulous communication between the bronchiectatic cavity of the right lower lobe and an enlarged bile passage. The latter was one of the main branches of the right hepatic duct in the ramifications of which two gallstones the size of cherry stones were found.

EICHHORST'S CASE<sup>63</sup>—An Italian man, aged 56, complained of cough and daily expectoration of from 200 to 500 cc. of greenish-brown bile. Examination revealed severe jaundice, dulness with diminished vocal fremitus in the right intrascapular space and tenderness in the region of the gallbladder. The trouble began in

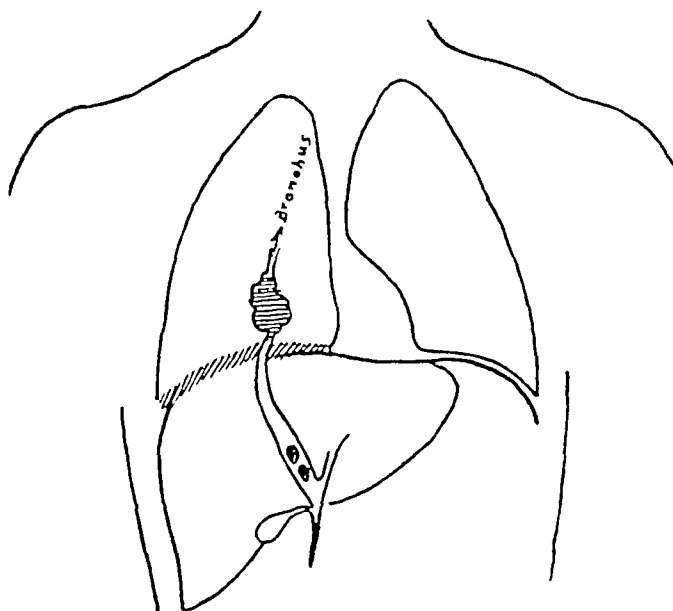


Fig 5 (Eichler's case)—Bronchiectatic cavity in the lower lobe of the right lung with a fistula connecting from the right hepatic duct which was blocked with stones.

October, 1901, with jaundice without apparent cause. In August 1902 he began to cough, and four weeks later he expectorated biliary fluid. There had been pain. The stool contained bile. An exploratory puncture of the right pleural cavity did not reveal any fluid even though the puncture was 10 cm deep. The condition was thought to be due to gallstones. Operation was refused.

ELLIOTT and HENRY'S CASE<sup>64</sup>—A septic hemothorax of the left chest caused by a shrapnel ball, which traversed both sides of the chest. When the wound was received, the patient began to expectorate sputum mixed with low bile, but the exact date of this could not be ascertained because the patient had caused a psychical obsession which made all the patient's statements question unreliable. On the twenty-sixth day, the empyema was completely drained. It contained streptococci and gas bacilli. From a postmortem examination



temperature was always between 37.7 and 39 C (99.8 and 102.2 F) A further record of this case was not given

**ROPER'S CASE**<sup>42</sup>—A woman, aged 56, had always suffered with bilious attacks In September, 1910, she had had typical gallstone colic, and one year before a slight attack of jaundice Before this she had had a similar, but less severe, attack of pain and had vomited and had slight jaundice In September, 1911, there was no bile in the stools A burning of the hands and the feet was experienced Under treatment, she gained 5 pounds (2.3 Kg) and bile reappeared in the stools In February 1912, she had an attack of pleurisy on the right side In the middle of March, 1912, the feces were pale The symptoms in the chest were diagnosed diaphragmatic pleurisy A rub was heard in the anterior part of the axillary space, the temperature was 103 Any motion was painful, and she could only lie flat on her back On March 16, she began to expectorate bile in the

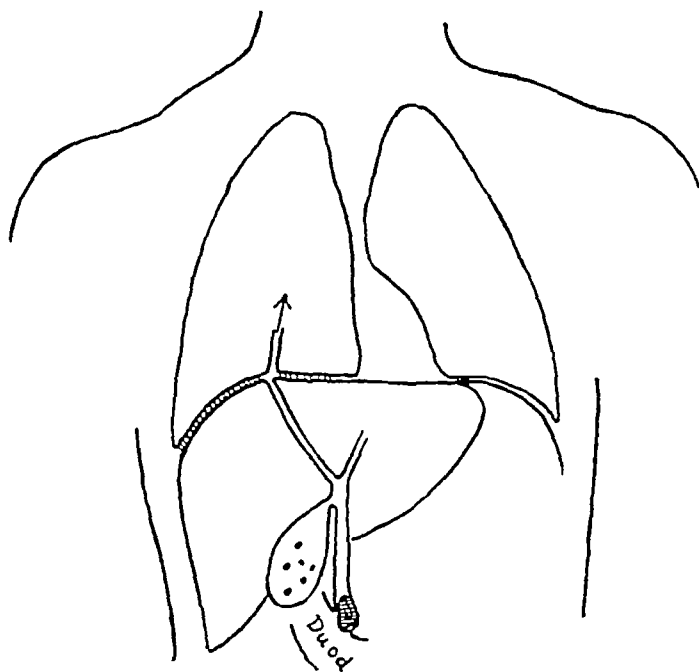


Fig 15 (Roper's case) —Fistula in the bronchus with a stone in the common duct and stones in the gallbladder

course of an ordinary cough On April 5, very faint icterus was present She coughed slightly every few minutes She expectorated about 2 teaspoonfuls of golden bile occasionally accompanied by a little mucus She sat erect in bed, because she thus reduced her cough to a minimum, lying back caused incessant coughing The cough was slight and suggested rather the welling up of fluid into a bronchus which at a given level caused a short, soft clearing cough totally different from the violent straining of bronchitis Twenty ounces of almost pure bile was raised in twenty-four hours, sucking in of lower right intercostal spaces occurred, she did not have dyspnea, and the percussion note was unaltered An insufficient amount of air entered the lower lobe of the right lung, there were marked expiratory sound and coarse râles, vocal fremitus and vocal resonance were absent The liver was plainly palpable 2 inches below the ribs, it was hard, but not tender The urine and the feces did not contain bile On April 9, an operation was performed A large distended gallbladder with some small stones was found, a hard mass in the common duct near the duodenum, measuring



was only a small amount of protein. A marked bile reaction occurred. A stained preparation showed a few polymorphonuclears and fewer eosinophils. There were numerous small diplococci. *Diplococcus lanceolatus* (extracellular), rare short chains of small streptococci and *Micrococcus catarrhalis* were found. *B. coli*, *B. tuberculosis*, or *Pseudomonas aeruginosa* was not present, otherwise the flora was that of the cavity of the mouth. Culture revealed streptococci and *Diplococcus lanceolatus*. Three days later, the man died from heart failure.

Postmortem examination revealed adhesions of the omentum to the colon and about the right lobe of the liver. A thick-walled passage 5 cm long and 2.5 cm wide on its inner circumference was found in the region of the gallbladder; it was lined with mucous membrane. Posteriorly, this passage widened somewhat. On the upper surface of the passage toward the liver, a blunt-edged gallstone the size of a pea was found in an ulcer. From this the cystic duct ran backward, 4 cm long, narrow and hard-walled. It opened into a markedly

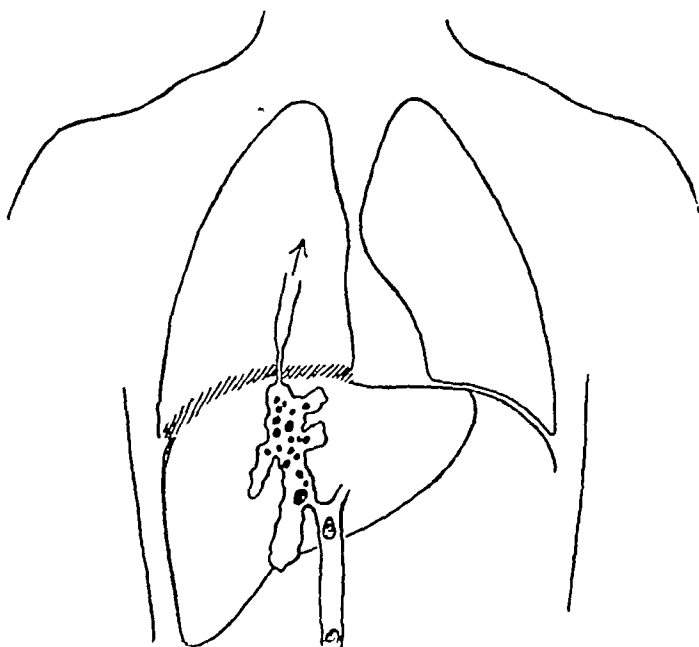
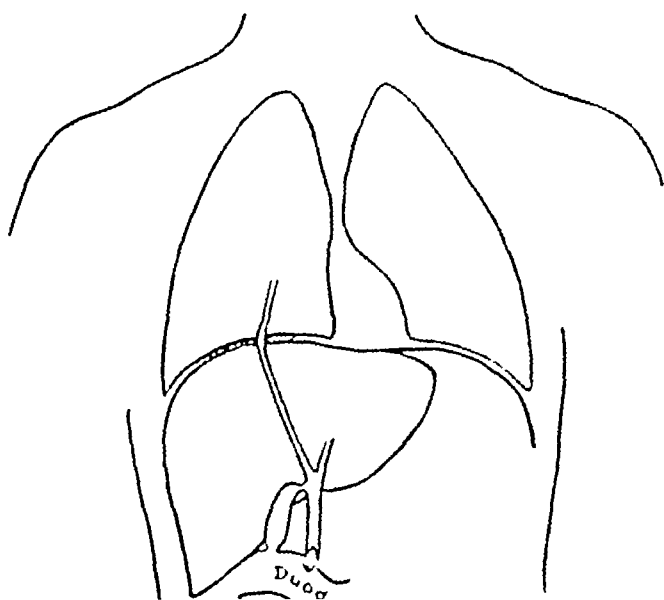


Fig 16 (Schlesinger's case) —Gallbladder connected with large cavity in the liver, full of stones, stones in lower end of the common duct, fistula through the diaphragm into the bronchus

widened common duct 3.5 cm in circumference, in which lay an oval gallstone the size of a hazelnut with rough surface, which could be pulverized between the fingers. On the upper surface of the liver, which was firmly adherent everywhere to the diaphragm, was a many-bayed, ramifying cavity with broader communications with the remnant of the gallbladder, with distinct, thick walls and a rather smooth inner surface. It contained over twenty blunt-edged, faceted gallstones varying in size from that of a pea to that of a bean. From this cavity a sharply circumscribed passage, the size of a pencil, led through the diaphragm and ran between this and the fast adherent lung posteriorly. It communicated with a bronchus the size of a goose quill, which led into the main right bronchus. The lung tissue in the region was pasty. The right lung contained numerous ramifying distinct cavities at the apex, with viscous shredded walls of scaly thickened tissue. The entire right lung was interspersed with numerous small, in places confluent, white-yellow, caseous patches at the base, usually with cavities in their center.

secretions. The stool was still completely colorless and steatorrheic. The sputum showed a slightly yellowish stain on February 9. It was carefully searched repeatedly for stones and pus, without results. On February 10 it became completely stained, and half formed, at the same time, a large three-facet, pigmented stone was found, the greatest diameter being 2.5 cm., the smallest 1.5 cm. The character of the sputum changed at once, no longer containing bile pigment, the quantity was not diminished, but became pure pus of a foetid type for the first time. There were marked rales over the lower lobe of the right lung anteriorly, the pleural sac remained free, and the temperature was normal. No more stones were found in the stools in spite of careful control up to February 19, but from then on several times great quantities of slimy pus was found. At this time, the cough and expectoration completely vanished, the patient regained health and left her bed. At the present time, she is well. The size of the gallstones and the amount of foul pus apparently showed that healing had occurred by means of a gallbladder-duodenal fistula.



material on March 28 and 29 and on April 1 and 2, after which the sputum lost its yellow egg-yolk color, became gray-yellow, then gray-white, and finally had the usual mucopurulent character of the sputum in chronic pneumonia. For about two weeks, the quantity varied from 500 to 600 cc daily, and stood in three layers, the middle layer being a thin fluid with masses. Hematoidin crystals were found for one week, but almost ten weeks after the onset, there were still fragments of crystals, later, these were not present. With the onset of the cough the fever began to drop. The tumefaction of the right hypochondrium diminished and left a depression under the right costal margin, signs of a cavity were demonstrated in the lower part of the right side of the thorax, anteriorly. The patient looked wasted during the summer of 1873. The stools became lighter and lighter, and in August were often paper white. The urine and the skin showed only a trace of icterus. Progressive emaciation was noted. By the end of June, there was intermittent fever to 40 C (104 F) every two or three days. In August, the fever diminished. In September, fever and intense icterus were noted. There was bile in the urine, and the skin was yellow. A tumor the size of a walnut appeared in the region of the gallbladder and disappeared after six days. There was color in the stool the day the tumor disappeared, the next day the stool was normal and they remained so from that time. The cough increased in intensity in September and the patient had fever, the temperature becoming as high as 40 C (104 F). In October and November, the bronchitis increased in severity and the patient became weak. Death occurred on Dec 23, 1873, after she had been in the hospital eleven months. The diagnosis was gallstones, abscess of the liver and a bronchial fistula (direct or through a subphrenic abscess), and pneumonia following diffuse bronchitis. Postmortem examination revealed the left lung adherent to the pleura, there were peribronchial and pneumonic patches. The right lung was entirely adherent, the tissue, especially of the lower posterior and middle parts was full of smaller and larger cavities communicating with dilated bronchi in many instances. There were fresh bronchopneumonic patches. The anterior surface of the liver was adherent to the wall of the abdomen, right transverse colon, right kidney and descending part of the duodenum. A wide cavity between the lung and the liver bordered on the ribs anteriorly and inferiorly, the upper surface of the liver was filled with a discolored fluid, mixed with slime and air. There was a smooth opening through the diaphragm to the bronchus in the lower lobe of the right lung. The cavity was larger than an apple, the right lobe of the liver was behind it, the dilated bile passage, below. A thin partition was found between the convex surface of the liver and the cavity in the liver, which in turn opened into the fistula. The gallbladder was very small. There was a fistulous opening from the common duct to a duodenal ulcer. The bile passages were widened. Two gallstones were found at the junction of the common duct, cystic duct and hepatic duct, one was the size of a hazelnut, the other, fragmented and the size of a pea.

**SINDERS CASE.**—A woman, aged 48, was admitted to the hospital on April 30, 1906. She had had measles, scarlet fever, pneumonia, puerperal fever and inflammation of the cecum. For six years, she had had pain under the right costal margin associated with jaundice, vomiting and fever, often severe. After two months, the attacks of pain recurred more severely, but they were accompanied by only slight jaundice. Eight days before admission to the hospital she had had a severe attack of vomiting of bile. Examination showed a fat, jaundiced woman, with a somewhat enlarged liver, but no tumor. On May 6, her temperature was 38 C (100.4 F). There was increasing pain in the region of the gallbladder. On May 8, operation was performed. From thirty to forty stones varying in size up

delicate, and had been admitted to the hospital twice during the last year for a syphilitic complaint. On May 17, toward 11 p. m., she suddenly became ill without any previous symptoms with violent pain in the right hypochondrium which kept her awake. She tried to get up in the morning, but had to return to bed. She vomited bile all day and night and came to the hospital the next day. During the examination, she held her hand over the right side, and pain radiated to her right shoulder. She was nauseated, but did not vomit, she had loss of appetite, but no jaundice. The stools were a gray, lead color and almost liquid. The urine was frankly icteric, chemical tests were positive for bile. The liver was not enlarged. From May 18 to 25, the condition remained the same, except that her temperature rose to 38 C (100.4 F) and she suffered from distention. Dyspnea began on May 26, and increased. The diagnosis was diaphragmatic pleurisy. On May 28, the phenomena of perihepatitis and peritonitis had almost disappeared, but pain persisted in the region of the liver and above it. Increasing difficulty in respiration was noted, the percussion note was dull, the breath sounds diminished, and fine rales were heard over the right lung in the back. The dry cough came in bouts. On May 29, there were more sharply defined signs of pleurisy. On May 30, after a bout of coughing in the night, a frothy yellow liquid which looked like bile, was expectorated. The expectoration contained bile, but no trace of pus, microscopically, it showed fat droplets, pus cells, and bilirubin crystals but no elastic fibers. The expectoration was pure bile. On June 1, the expectoration continued, being more abundant by day than by night. The patient was dyspneic, only a trace of bile was found in the urine. On June 2, there was no bile in the urine. On June 5, the expectoration increased to 700 cc. From June 6 to 9, the expectoration diminished to nothing, the cough was rare and dry. On June 10, she felt increasing oppression, and had a sudden bout of coughing with filling up of the lungs. The sputum became thicker and less yellow. A new analysis showed a diminution of bile and an absence of pus. Aspiration was performed without result. On June 11, the patient had a good night, without cough or expectoration. On June 15, she was well and she was discharged from the hospital on June 30.

**GASTON'S CASE.**—A middle-aged man had severe symptoms of impacted biliary calculi, including absence of bile from the stools, jaundice, itching and tenderness over a fixed point a little to the right and below the ensiform cartilage. There was also peculiar and persistent pain in the right arm. There was sudden improvement in the patient's condition, with a change in the character of the stool, which contained a number of gallstones. The size of some of these gallstones caused the author to suspect that there was an ulcerated communication with the bowel. The patient became convalescent and went from the United States to Brazil. A few weeks later, he came home again, he expectorated an offensive bile stained sputum, and died within a few days after reaching the United States. Postmortem examination showed, ulcerations connecting the gallbladder with the duodenum, and an opening through the diaphragm into the lungs which were adherent to the diaphragm. The common duct was completely closed, its walls were thick and hardened. The collection of disorganized bile and serous exudate, which doubtless was originally confined in the dilated sac of the gallbladder, had made its way into a cavity formed between the upper surface of the liver and the lower surface of the diaphragm and extended through the aperture into the pulmonary structure. The flow of this offensive matter into the bronchial tubes seemed to be the immediate cause of death.

**GRAHAM'S CASE 1.**—A man, aged 33, had had but one illness, which occurred three years before his case was reported. He was seized with pain in the region of

about the bronchi. On Jan 10, 1908, the patient was recovering slowly. The sputum was slight. On March 11, the lung-lip fistula remained. On March 16, operation was performed, the scar and nearest rib were resected. The lung was freed from the diaphragm and wall of the thorax. On April 14, two small bronchi still were open. On August 8, the patient was discharged with the wound healed. On March 24, 1909, she reported that the wound had broken open on March 14, and had discharged a small amount of yellow secretion, but had again healed. The chest was in a satisfactory condition at the time this report was made, but the patient still complained of pain in the scar in the epigastrium. On June 22, the patient entered the hospital again with intermittent pain in the epigastrium, fever as high as 40 C (104 F), and icterus. The scar again opened in the back, discharging a yellow secretion. On July 11, a sudden sharp pain was felt in the epigastrium, there was slight icterus. An operation was performed and the old wound was opened. There were adhesions between the anterior surface of the stomach and under surface of the liver as well as between the upper surface of the liver and the diaphragm. A large faceted stone was found in the common duct behind the duodenum, then numerous small ones and finally broken stones. On August 2, the drain was removed. On September 21, erysipelas developed on the front of the wound and on the abdomen and shoulder. On October 11, a sudden sharp pain was felt in the abdomen and the patient was in a state of collapse. On October 17, the patient's condition was good, the appearance of the wound was satisfactory. After five weeks of fever, the wound healed. From November 23 to 28, the temperature was normal. From November 28 to December 10, there was a rise in temperature during the evening from 38.1 to 39.5 C (100.5 to 103.1 F), the wounds were diminishing and the fistula in the lung closed. Otherwise, the patient's condition was normal.

SMITH and RIGBY'S CASE.<sup>46</sup>—A woman, aged 50, was admitted to the hospital on Dec 14, 1902. Eighteen months previously she had been in the hospital on account of acute symptoms of cholangitis probably due to gall stones. Pain had developed in the right upper quadrant, associated with pyrexia and jaundice, but all the symptoms had subsided without operation. Since leaving the hospital, she had had attacks of abdominal pain from time to time, which lasted from one to two hours, usually after eating, both the onset and the end of these attacks were sudden. The skin was yellowish on several occasions, but never deeply jaundiced. For the last three months, she had suffered from pain in the back and in the right shoulder without relation to food, the pain was not severe. Ten days before admission she had had a severe fit of coughing accompanied by expectoration of green fluid with a very bitter taste. Since then a distressing cough and expectoration of similar fluid had persisted. Examination revealed a fairly well nourished person with a normal color. The conjunctivae were a little yellow. She complained greatly of cough, which was frequent and distressing. After each fit of coughing, she raised, with little effort, 1 or 2 drachms of dark green, frothy fluid expectoration with a bitter, unpleasant taste. She could not lie down owing to this constant desire to cough, she did not have a fever. The lungs were emphysematous and hyperresonant, expiration was prolonged, and rhonchi and râles were audible on both sides. The liver was palpated two fingerbreadths below the costal margin, superiorly it was not enlarged, there was slight tenderness on palpation over the region of the gallbladder, there was no rub. The sputum gave a characteristic reaction for bile. The urine and the stools were normal. For three weeks the condition remained unchanged. From 20 to 30 ounces of sputum was expectorated daily. On Jan 5, 1903, the patient complained of increasing pain in the right hypochondriac region. On examination, it was found

of bile being less daily, until it suddenly ceased on December 19. He was back to work Jan 1, 1887. During the attack, the bowels were constipated, the feces were a light grayish color. He remained well until April 13, when he began to cough while riding in a street car. He had a choking sensation and expectorated bile. There was no pain. After four or five days, he was back at work. On April 21, examination was normal. From April, 1887, for over ten years, he was in good health, except for alternating attacks of constipation and diarrhea. During the latter part of this time, he noticed light colored stools and itching. In early May, 1896, he noticed that he began to be jaundiced. On May 31, he felt a sudden severe pain in the region of the gallbladder, which gradually increased, and soon after the onset, he coughed up a greenish fluid. He remained in bed for one month. At that time the urine was dark red. The attack passed away in two weeks. He continued to cough up bile from May 31 to November 22, with the exception of two or three days when he expectorated a large amount of mucus. The amount of bile varied from a few ounces to 2 pints. The skin was not normal in color, but it was not remarkably jaundiced. When the expectoration ceased, the jaundice deepened. On Nov 20, 1896, he showed slight distention. A distinct swelling that was more or less tender and somewhat elastic was noticed below the costal margin. He complained of pain in the region of the gallbladder. The spells of coughing were more distressing when he was in a recumbent position. The sputum contained bile and mucus but no pus. Vocal fremitus was slightly increased on the right side. Dulness was elicited on percussion from 1 to 2 inches (2.5 to 5 cm) higher than normal between the midaxilla and the sternum. Various rales were heard in the same area, also friction. There were small amounts of bile in the urine. During the cough, the patient was cyanosed. The temperature varied from subnormal to normal, but was never elevated. In December and January, 1897, he again coughed up bile, the amount varying from  $\frac{1}{2}$  to 2 pints and it was mixed with frothy mucus. Gmelin's test was positive. The patient's general health declined during the summer, and he was much weaker in December. On Jan 26, 1897, an operation was performed. From 6 to 7 ounces (157.4 to 187 cc) of dark bile were aspirated from the gallbladder, the common and hepatic ducts were full of stones. The ducts were over one-half inch (1.27 cm) in diameter. A cholecystenterostomy was performed, the hepatic flexure of the colon being used. The patient died on the twelfth day from hemorrhage. He coughed up less bile after the sixth postoperative day. The cough tore open the suture line on the third day. On the sixth day, he coughed up material suggesting fecal contents, but it was negative for *B. coli*. The temperature rose. There was a consolidation in the lower part of the anterior right lung and the patient suffered from hemoptysis. The sputum contained blood and bile. On the ninth day, the blood increased. Death occurred on the twelfth day. A postmortem examination was not performed.

GRAHAM'S CASE 2<sup>o</sup>—A man, aged 25, was in excellent health up to the time of an accident. On January 28, he was kicked by a horse over the cartilages of the fifth, sixth, seventh and eighth ribs. He was not knocked down and there was no marked contusion or injury to the cartilages. He immediately felt a severe pain beneath the part struck and in the right shoulder. He walked to the house and the pain increased. Four hours later, he suffered intense spasmodic pain in the hepatic region and in the shoulder. The abdomen was much distended. There were frequent eructations of gas, which relieved the pain. He expectorated mucus tinged with blood. The pain was relieved by morphine for four days, then pneumonia developed in the lower anterior part of the lung, the inflammation subsided in about a week, but the consolidation remained. Fluid formed in the



**STUMPF'S CASE**<sup>30</sup> (according to Burgess) —A woman, aged 50, suffered from attacks of biliary colic from 1903 to 1907. She was operated on Dec 19, 1907, and showed a perforation of the gallbladder with considerable infiltration along the common duct. Cholecystectomy was performed with gauze drainage. The wound discharged for two months, then healed. In June, 1912, she had diffuse bronchitis with a blood-tinged expectoration. Examination revealed the spleen and the liver enlarged and firm, albuminuria, 5 per cent. On August 24, the woman was knocked down by a bicycle. Three days later, she had severe pain in the right side and coughed up large quantities of thin, yellow, frothy mucus, the stools became colorless. Afterward, days of expectoration of bile alternated with days free from such expectoration. On September 16, pleurisy associated with effusion developed in the right side, but the fluid was free from bile. Eleven days later the expectoration of bile finally ceased. On November 14, death occurred after two days of peritonitis. Autopsy showed diffuse peritonitis, apparently extending

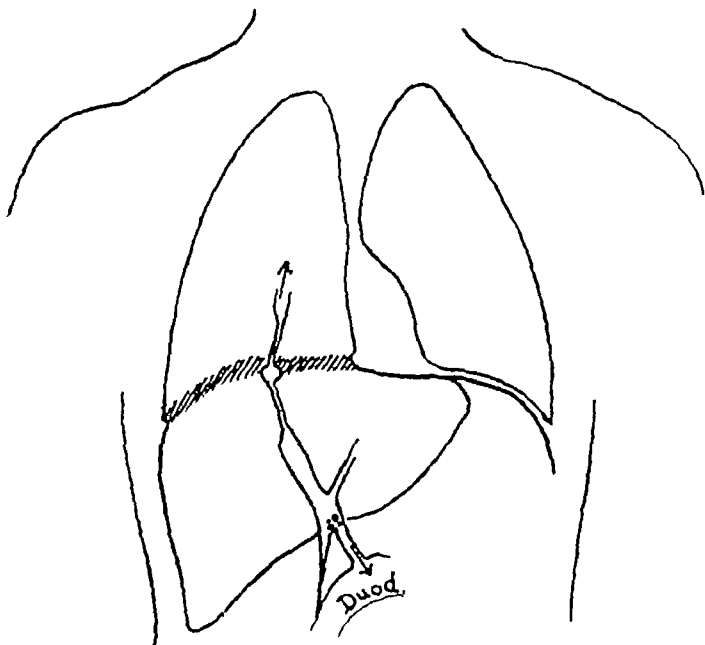


Fig 18 (Stumpff's case) —Gallbladder has been removed, common duct obliterated by scar tissue, fistula to the duodenum from dilated ducts, stones still present in the biliary ducts

from a phrenopneumosis, extensive adhesions of both the right lung and the right lobe of the liver to the diaphragm, and a small cavity the size of a pea at the posterior upper surface of the liver in the midst of the adhesions. This cavity contained bile-stained fluid and communicated both with a bronchus and with the bile ducts. The main bile ducts were much dilated. The lower end of the common duct was completely obliterated. A narrow fistula was present between the common duct and the duodenum just beyond the pylorus. Several small calculi and some bile sand were found in the common duct, the calculi being just sufficiently large to produce an intermittent complete blocking of the fistula.

**TUCKWELL'S CASE**<sup>31</sup> —A woman, aged 60, was admitted to the hospital on Jan 22, 1870. For six years, she had had severe attacks of vomiting, pain in the epigastrium and jaundice. Each attack lasted from three to six weeks. The last attack had occurred ten weeks before admission. The present one began the day of admission, with severe pain in the epigastrium and back, accompanied by vomiting

IDO and YASUDA'S CASE.—A woman, aged 20, who was admitted to the hospital on April 20, 1910, had suddenly had a boring pain in the epigastrium one night, it did not radiate, and continued for a week. At the age of 17, she had suffered from general weakness and malaise and icteric urine without demonstrable cause, a week later, she had had icterus. In the course of the disease, symptoms of pneumonia had developed suddenly. A bitter tasting sputum varying in color from that of an egg yolk to a greenish color was expectorated in large amounts. After three weeks the patient had recovered. Since that time, attacks of coughing would occur, after a rise in temperature, and the patient would expectorate gall-like sputum. Attacks of from five to fourteen days' duration recurred many times yearly.

Physical examination revealed an infantile person, backward in development, poorly nourished, and slightly anemic. The epigastrium was slightly sensitive to pressure, dullness of the liver in the right mammary line began at the fourth rib,

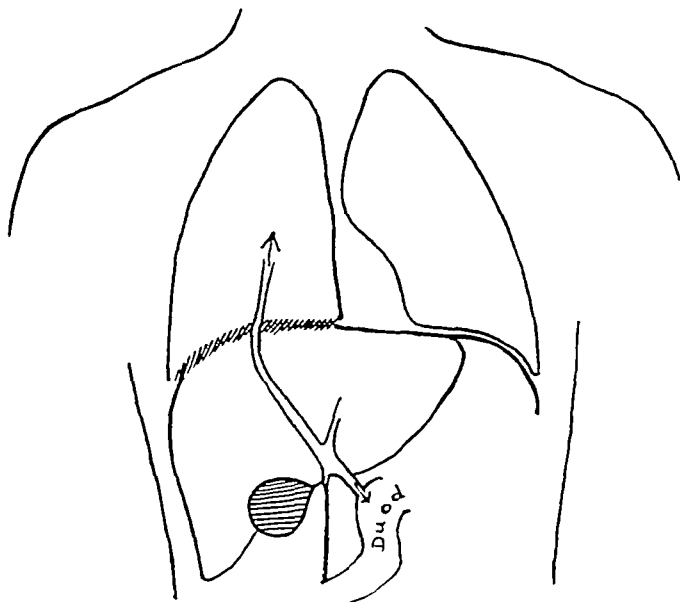


Fig 9 (Ido and Yasuda's case)—Empyema of the gallbladder and fibrous pericholangitis, spontaneous fistula of bile ducts to duodenum and fistulous opening through the diaphragm to the bronchi

the lower border being hard and sharply defined, and three fingerbreadths below the costal margin. The surface of the liver was uneven, knobby and coarsely granular. The spleen was somewhat hard and enlarged. The feces were pale and foul. Parasites were not found. There was a slightly dull area anteriorly and posteriorly at the base of the right lung, and there were signs of bronchitis in the remaining parts of the lungs. Sputum was expectorated in small amounts, at this time, it was colorless, foamy and slimy, showing microscopic pus cells, lung epithelium and various micro-organisms. Results of examination for tuberculosis bacilli were negative. There were Hemoglobin, 62 per cent, red blood cells, 2,670,000, and white blood cells, 10,000. The Wassermann reaction was positive. The urine was icteric. There was a distinct reaction to Gmelin's test, and there were traces of urobilin and albumin. A roentgenogram showed a diffuse broad shadow in the lower part of the right lung. On the third day, the temperature was from 38.9 to 39.4 C, a dull pain was felt in the right side of the

communicated below with the open-mouthed branches of the hepatic duct. The gallbladder was filled with dark bile and numerous gallstones of varying sizes. The common duct was dilated widely by a calculus the size of a small bean at the duodenal opening. The hepatic duct was blocked by a large dark concretion, which sent shoots into all the large terminal branches of the duct. All the bile ducts were much dilated. The fistulous opening was large enough to admit a small catheter. The opening led through the diaphragm from the pleura to a smaller suppurative cavity in the liver (an offshoot from the large abscess) and thence by a large open-mouthed branch of the hepatic duct into contact with one of the offshoots from the large concretion.

**TYRMAN'S CASE**<sup>28</sup>—A man, aged 22, was admitted to the hospital on Nov 18, 1908. He had fired a shot from a small caliber service rifle toward his right breast after being scorned in love, and had been picked up on the street, given first aid and brought into the hospital one hour later. Examination revealed marked collapse, outspoken pallor, a state of shock and bloody sputum. There was a hole the size of two farthings in the right mammary line at the fifth rib, the surrounding area was stained black. The exit wound, the size of one farthing, was in the right scapular line between the ninth and tenth ribs, there was a sucking wound. Dulness was heard over the right thorax, and tympany to dulness at the right apex. The patient was treated for shock, and the wounds were packed. Bleeding from wounds continued for three or four days, and the patient's condition remained unchanged. On November 25, the dressings were soaked with bile. Nearly 1,200 Gm of necrotic tissue cells, pus and fibrin were drained. The stool and the urine were normal. On November 27, dressings were applied three times a day, the output of bile lessening generally. On November 29, there was about 800 Gm of secretion, demonstrably more after eating, most marked on sitting up. To the author's amazement, the patient coughed up a quantity, from about 80 to 100 Gm, of slimy green bile, mixed with pus cells and very bitter to the taste. In the sputum glass, there was a larger lower layer of greenish thin fluid and an upper layer of clear, foamy, whitish-yellow fluid. From November 30 to December 21, the bile from the wound diminished to about 600 Gm daily, there was more when the patient was in an upright position and sitting than when he was lying down. About 50 Gm of secretion was coughed up daily. On December 22, under chloroform anesthesia, the fifth and sixth ribs were resected for about 12 cm. toward the axillary line. Adhesions between the lung and the diaphragm were freed by blunt dissection. A resistant strand about the size of a finger with a broad base was separated by instruments. A large wedge-shaped cavity was found with thick connective tissue walls, tenting up the diaphragm two finger-breadths at the place of separation of the strand. Possibly part of this may have been due to the convexity of the liver. At the base of the strand and immediately adjacent to it, there was seepage of bile. On December 23, a slight amount of biliary sputum was expectorated, an irritating cough was present, only a slight seepage of bile occurred. The record made on January 14, was that the course of the illness was uneventful, the wound had closed.

**VAN WIJHE and HAMMER'S CASE**<sup>29</sup>—A woman, aged 57, entered the hospital on Aug 7, 1920, with a complaint of hemoptysis. For fourteen days she had been coughing and expectorating bile. Since November, 1919, she had remained continually sick with grip, but it had not prevented her from working. Examination showed a small woman with kyphosis and emphysema, but no icterus. There was residual pneumonia in the lower part of the right lung. The liver was somewhat enlarged, but not painful on pressure. In 1883 and 1885, she had been admitted to the hospital and had been shown at the Congress of Dutch Surgeons. She had

of the edge of the liver was sensitive on pressure. The dulness of the liver was lower than normal, the upper border being in the seventh interspace. Few rales were heard over the dull tympanitic zone. On September 28, operation was performed, the liver showed venous hyperemia. The gallbladder was large and the entire region was bound down with wide dense adhesions. The gallbladder was opened and emptied of 50 cc of dark green clear bile and soft stone (this could be mashed up with the fingers to a paste). Other stones were not palpable. A fistula could not be found. The gallbladder was drained. The condition ran its course without fever or complications. After waking, the patient coughed up a minimal amount of biliary fluid. From the afternoon of operation, the cough which raised bile ceased, and bile did not flow from the drain. Eight days after operation, the stool was colored. Only mucus came from the drain. On November 3, the patient was well. She left the hospital and went to work. Two

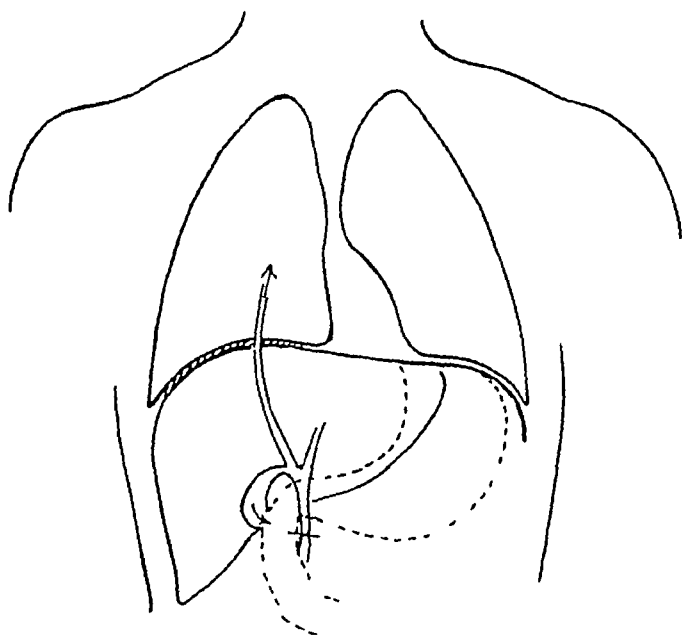


Fig 10 (Kehr's case) —Spontaneous healing of pulmonary fistula by cholecystenterostomy

years later (October, 1908), she again had pain in the epigastrium, vomited, was jaundiced and had acholic stools. The expectoration was stained a slight yellow once (the patient suffered from chronic bronchitis), but bile was never coughed up again. On Feb 2, 1909, an operation was performed. There were adhesions to the intestines and the liver adhered to the abdominal wall. The gallbladder was the size of a hen's egg. There was a tear on the medial side of the former operative site, from which a white, thick, odorless fluid emptied. Suddenly, a white bladder appeared in the operative field. Echinococcus was found in the liver and adhesions separated in the region of the hepatic duct from the liver, a hard crackling paper-like mass was palpable, manifestly a calcified echinococcal wall. The cyst cavity was many chambered and very deep. Both the mother and daughter cysts were expressed. Two drains were inserted. On the following day, bile flowed from the cyst in the liver cavity. The stools were acholic for five weeks. The jaundice cleared up and the wound healed slowly. Another incision was made posteriorly under the twelfth rib. The fistula closed on May 24, and the patient was discharged on June 5.

pain in the abdomen, especially in the right lower quadrant, and repeated vomiting. He was bathed in perspiration and felt cold, the pulse was scarcely palpable, and the rate was rapid. There was an outspoken picture of threatened collapse and marked meteorism. Pain developed in the region of the cecum. Slight pressure here was painful. Considerable swelling of the liver was noted, the lower edge was two fingerbreadths below the costal margin. During the next week, the pain became localized more and more to the region of the liver. There was a marked swelling of the liver, one handbreadth below the costal margin. The patient became jaundiced and had clay-colored stools. The gallbladder was palpable, it was the size of a small apple and sensitive. The general condition was very unsatisfactory. On August 1, he had a chill with fever to 41 C (105.8 F), severe dyspnea, a picture of pleurisy of the right side and a painful cough with slimy sputum. Dulness was heard over an area, a handbreadth in width to right lateral and posterior part of the thorax. On August 10, the chest was

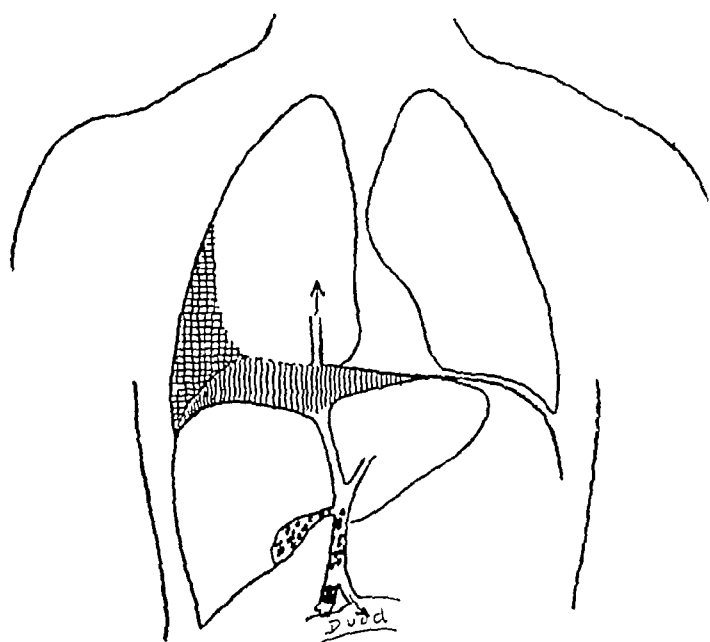


Fig. 21 (Weiler's case) —Subphrenic abscess, empyema, stone in the common duct and gallbladder, spontaneous fistula to duodenum and fistula to bronchi.

tapped, but no fluid was obtained, the patient refused a second puncture. With the onset of pleurisy and other symptoms, the swelling of the liver and gallbladder diminished. The gallbladder was no longer palpable. The pain disappeared. During September, he coughed up large quantities of foul sputum daily, which varied from pure pus in the course of next two days to egg-yolk stained sputum, and then to a strikingly thin fluid consistency. The patient complained of a bitter gall taste. The jaundice was reduced, and there were fewer clay-colored stools, there was a small amount of bile in the urine. On December 27, the patient coughed up gallstones. There was rapid improvement throughout January.

WEILER'S CASE<sup>66</sup>—A woman, aged 45, entered the hospital on April 20, 1901. Twenty years previously she had had pleurisy on the left side. Ten years and six years previously she had had gallstone colic. She had been cured at Karlsbad. The patient said that her color had been very yellow, but that she did not know when the gallstones had passed. Ten days before admission, she became weak,

lung was adherent in toto to the ribs and to the diaphragm, in which there was an opening of 22 mm communicating with the hepatic parenchyma and with the pulmonary tissue, there was a cavity with calcified walls with infiltration of biliary pigment. The duration of the condition was twenty-one months.

MACDONALD'S CASE<sup>22</sup>—A butcher, aged 49, was admitted to the hospital on April 12, 1890. He had had syphilis in 1864, and in 1872 had lost his right eye and the whole soft palate through syphilitic ulceration. He had had malarial fever five months previously. One month before admission, he had had a dry cough which lasted one week. At the end of that time he had coughed up a large amount of purulent material. For two weeks this type of expectoration had continued, and he had easily raised large amounts when he leaned forward. The sputum had become thicker and less in amount and a few days before admission it had become dark. Physical examination revealed a poorly nourished man. Submucous crepitant râles were heard over the whole of the right lung, but were more marked toward the base, râles were heard also over the posterior lobe of the left lung. A constant irritable cough developed. The liver was palpable to within 1 inch (2.5 cm.) of the umbilicus. The expectoration was frothy and brownish. On April 20, a large amount of mucus heavily charged with bile was expectorated. The cough continued to be especially violent at night. The expectoration stained his moustache, beard and handkerchief a bright yellow. Bile was absent from the stools. On April 27, the expectoration increased in amount. The conjunctivæ had an icteric tint. The urine was the color of porter. Slight anasarca occurred in the right foot. On May 1, the biliary sputum had increased, an almost incredible amount of bile thus being expectorated. Most of it was raised from one half to one hour after eating food. The cough kept the man and the other patients awake. The stools were free from bile. On May 20, all expectoration ceased and none was raised for four days, but after that it appeared in increased amounts. On May 30, the râles had cleared up. The dulness of the liver had diminished. The stools were still white. He was put on antisyphilitic treatment because it was believed that the obstruction was due to a syphilitic lesion which caused either occlusion of the hepatic duct by ulceration or more probably a gummatous growth pressing on it. On June 7, he was apparently improved. The cough and biliary expectoration was less. On June 19, the cough and biliary expectoration had ceased. Bile now appeared in the stools for the first time since April 20. On July 14, he was discharged. The abdomen showed a slight amount of ascites. The condition of the lungs was satisfactory. On July 15, he presented himself again. He had a violent attack of coughing during which he expectorated three small biliary calculi, two of which were faceted and about the size of a split pea, the other about one third of an inch long and one eighth of an inch in diameter forming a perfect coil of a tube (bronchial?). The cough ceased after the stones were coughed up. The patient has since returned to work feeling well, and has not suffered pain or colic of any kind.

MANDARD'S CASE<sup>23</sup>—A man, aged 70, became sick in November, 1849. For some time he had suffered with vague and irregular pains at the base of the chest, until he was seized with fever, dyspnea, cough and violent pain in the right thoracic region. A diagnosis of pneumonia at the base was made. The disease did not follow the regular course, and instead of terminating by resolution, passed to a chronic stage. There was abundant expectoration of purulent sputum, which was thought to be due to an abscess of the lung, but the sputum soon took on other characters. It became brown green, then bilious. At the same time, the amount of expectoration increased definitely, with fits of coughing which brought up quantities of bile. On auscultation, there were all the signs of a cavity at

and ceased altogether about a month after operation. He was discharged on Jan. 9, 1922, feeling well and free from cough, having gained several pounds in weight. The wound was healed. Crepitus at the right base of the lung had disappeared, but some dulness remained. Signs in the abdomen were unchanged. Six months later, he was well and doing full work. He regained his former weight. The enlarged veins of the abdominal wall had disappeared, and the only sign present in the right side of the chest was a slight persistent dulness.

urine From 1 to 1½ pints of extremely offensive bile and pus was coughed up in twenty-four hours The pus was crowded with bacteria There were no tubercle bacilli or elastic fibers, and manifestly the pus was not caused by a bronchiectasis On May 21, 1903, operation was performed The liver was enlarged and cirrhotic There were firm adhesions from an old shrunken gall-bladder and the lower surface of the liver to the stomach, duodenum and colon A gallstone the size of a small nut was found impacted in the hepatic duct It was removed Numerous adhesions were found between the dome of the liver and the diaphragm The hepatic duct was drained The expectoration of bile was immediately arrested, but pus continued The expectoration of bile returned on the third day, and then gradually became less The cough gradually diminished, and the purulent expectoration rapidly decreased The wound healed in a month Two months later, the patient was much improved, and was gaining weight

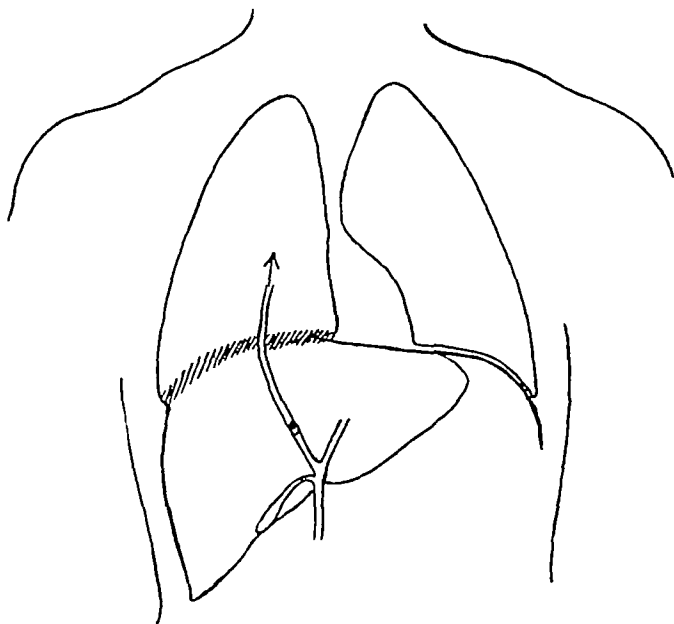


Fig 12 (Mayo-Robson's case) —Fistula to the bronchus due to a stone in the right hepatic duct

rapidly, coughing up only small quantities of mucopus without bile There was no jaundice, all bile passing by the bowel

NERMORD'S CASE.<sup>51</sup>—A woman, aged 50, was admitted to the hospital on April 13, 1891 She had had scarlatina at 10 and angina at 17 She was always well until 1883, when she suddenly had a chill and vomited bile (about a basin full) Immediately after that, continuous pain developed, which was localized to the right hypochondrium It was so intense that she could not bear the weight of even a sheet in that region In the evening it was noticed that she had become yellow all over and that the stools were white The pain lasted four or five days, but disappeared following the use of purgatives, then the jaundice lessened and the stools became colored She remained weak for three or four weeks, her appetite returning little by little Every year for eight years, she had two or three days of acute pain in the right hypochondrium, accompanied by a subicteric tint of the skin and decoloration of the feces, but this condition cleared up promptly and she resumed work In October, 1890, there was renewed pain, but it was less than usual, jaundice occurred, and the stools soon became



neck on the right. A slight swelling without discoloration was noted, and hot applications were advised by his physician. As the swelling and slight pain did not improve, he was referred to me, April 7, 1923.

*Physical Examination*—The patient was well developed and weighed about 140 pounds (63.5 Kg), his physical examination was normal, except the right upper arm. A marked swelling of the outer side of the right upper arm, over the prominence and insertion of the deltoid muscle was present. The skin was normal in color over this area, and neither dilated nor enlarged veins were noted. The mass was markedly indurated, nearly bony in consistency, smooth and not lobulated.

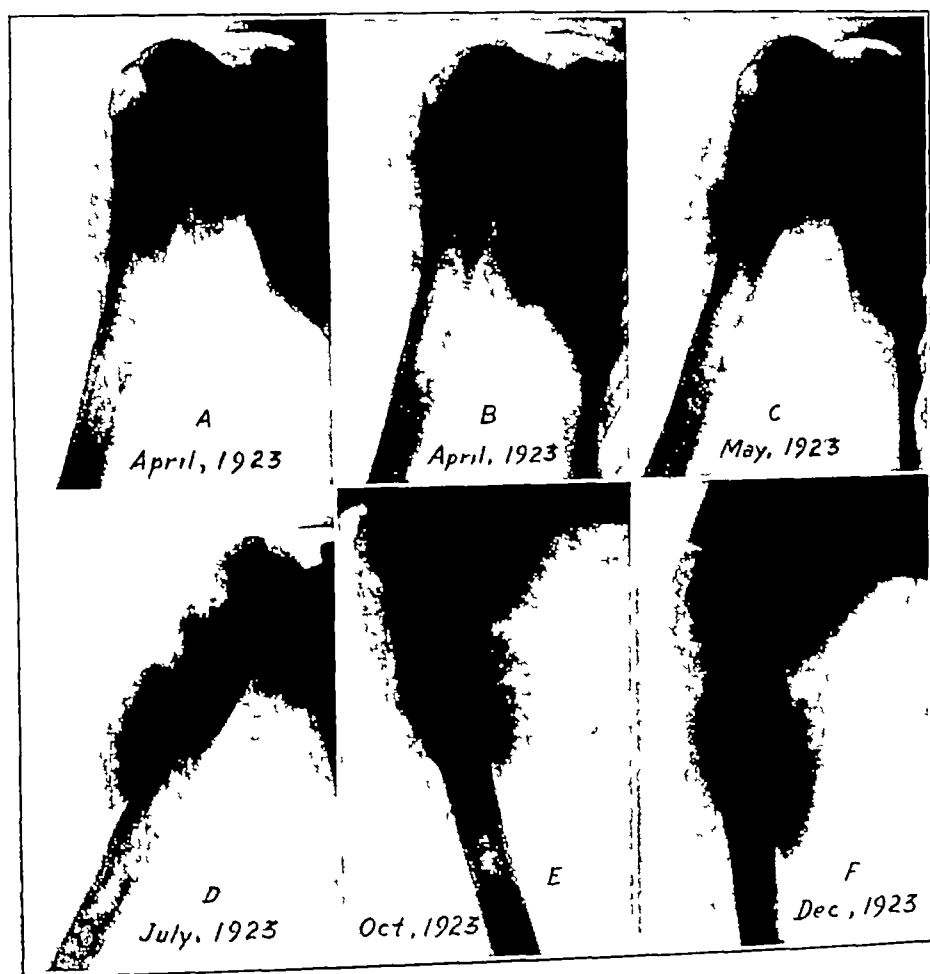


Fig. 1—A and B present the roentgenographic appearance one month after injury, showing beginning bone formation in soft parts. C, D, E and F show the increasing bony formation.

and impressed one as being in the deltoid muscle, the skin was movable over the mass and the growth was slightly movable over the humerus. The mass was slightly painful on pressure and on full extension of the arm over the head. Motion of the shoulder, elbow, wrist, or fingers was not limited. The grip was normal. The radial pulse was the same as on the left side. Roentgenograms taken at this time (A and B in fig. 1) showed a definite bone-forming tumor of the outer side of the right humerus, which was thought to be due to the stripping up of periosteum at the insertion of the deltoid muscle, the result of indirect violence one month previously.

thick dark green bile on which floated some nummular material was coughed up. The patient was very tired. On May 3, 500 Gm was expectorated. On May 5, the sputum was so thick that she was scarcely able to expectorate it. Acute pain had developed in the right hypochondrium the day before, radiating to the right shoulder. She was very much oppressed, and continued to lose strength, the least movement caused fatigue. A puncture was performed near the right kidney and a slightly bile stained liquid was removed. Death occurred on May 6 at 10 a. m. All the time she was in the hospital the feces were without color.

Autopsy revealed an enlarged liver, with a slightly irregular, granular, green colored surface. The extra hepatic and intrahepatic bile channels were greatly enlarged and crammed with biliary calculi. The common duct was the size of the small intestine. There was a large calculus at the intestinal orifice. The gall-bladder was adherent to the duodenum by its fundus. It contained biliary calculi and little bile. On cutting the liver, the bile channels were dilated and filled with calculi in considerable quantities as if a solid had been injected and then fragmented. They were bathed in a purulent greenish liquid. The liver, diaphragm and base of the right lung were adherent at the posterior costodiaphragmatic sinus. Here there was a cavity the size of mandarin with irregular walls flattened from above. It contained a green liquid mixed with pus and bile. The fistulous tract on the biliary side could not be found, but on the pulmonary side it was traced through to the bronchus.

OETIKER'S CASE<sup>25</sup>—A man, aged 46, was admitted to the hospital on Sept. 10, 1925. His health had been good until one year previously, when he became ill with icterus and an enlarged liver. After a rest, he felt fairly well and worked until three months before he was admitted to the hospital. At this time icterus again appeared and disappeared together with a sudden onset of a cough with the expectoration of bile. There was no pain, but striking emaciation and weakness. Examination shows sclerae with a subicteric tint, otherwise there were no signs of jaundice. The liver was firm and somewhat enlarged. It was painful, and there was a nodular tumor of the left lobe reaching almost to the umbilicus, it was only slightly displaced on respiration. An area of dullness like a second heart figure mounted over the dullness of the liver two fingerbreadths to the right of the sternum. He had emphysema of the lung, bronchitis and pleurisy in an area the breadth of the hand in the right posterior inferior part of the chest. There was a daily expectoration of bile mixed with mucus varying in quantity from 800 to 1,100 cc. The appetite was good. There was no vomiting, and the stools were acholic. The temperature was normal in the morning, in the evening it rose to 37.8 C (100 F) and exceptionally to 38.4 C (101.1 F). In a roentgenogram, the upper edge of the liver was indistinct and passed over into a cloudy consolidation of the right lower lobe. When iodized oil 40 per cent was injected, the bronchi of the lower lobe appeared widened with irregular inlets, especially in the thickened part. Further examination after four days did not show any iodized oil in the liver. The sputum did not contain any tumor cells, scolices or hooklets. Eosinophilia did not occur. The Weinberg and intracutaneous tests with echinococcus fluid were negative. A differential diagnosis was made between abscess, tuberculosis, echinococcus and malignant disease of the liver with a breaking through and encroachment on the lung. It was decided a definite diagnosis could not be made. The condition was probably multilocular echinococcus or carcinoma.

The patient asked urgently for operative relief because of the extraordinarily troublesome cough which gave him no rest at night. When the abdomen was



Fig 3—Appearance of tissue removed at first operation

PARSON'S CASE<sup>64</sup>—A young man was seen on February 2, with a temperature of 103 F, he had a pulse rate of 128 and a very dark skin. Extreme tenderness was elicited in the right hypogastrium with considerable swelling and dulness extending above the costal cartilage. Deep percussion revealed the left border of the liver 5 inches (127 cm) to the left of the median line. The gallbladder was also greatly distended. Expectant treatment was instituted. The condition remained unchanged for five days. The stools were white and the urine contained bile. On February 7, a dry hard cough developed and on February 8, he began to expectorate large quantities of bile, shown by nitric acid and Pettenkoffer's test. He became delirious and sank rapidly. On February 10, the sputum became normal in color. An enema gave a healthy dark passage from the bowels. Convalescence was rapid and on February 14, he was about the house, though he was much emaciated.

PERRIER'S CASE<sup>65</sup>—A man, aged 34, was admitted to the hospital on April 30, 1900. He gave a negative history as to his present illness. Eleven years previously he had noticed a sharp pain in the region of the liver on the right side. Some days later, a frank hepatic colic developed. One month later, he had another attack which lasted eight days. Every year since, he had had similar attacks during the month of December. During the interval, he was well and did not have any symptoms. He was said to have had pleurisy on the right side five years before admission. He remained at rest for a month. The symptoms were slight so he did not remain in bed. In March, 1899, his color turned yellow some days after he had noticed that his urine had a dark tint. The jaundice increased until the end of June. He was weak, but did not suffer. Pigmentation then diminished rapidly, but he felt ill at ease and tired and was without forcefulness or courage. A tumor appeared in the epigastrium, and the right side of the hypochondrium was enlarged. The pain became severe, immobilizing him completely. He vomited often. That winter the tumor diminished soon after the appearance of a troublesome cough, accompanied by expectoration of bile. The cough was almost continuous for six weeks. He spat up almost continuously small mouthfuls of a greenish foamy, often very bitter liquid. Sleep was impossible on account of the asphyxia. He could sleep a little with his head supported against the bed. He suffered from considerable weakness and emaciation. The liver and the spleen were enlarged, over the lower fifth of the right lung posteriorly there was a zone of tympany, the percussion note was flat. Breath sounds were diminished. There were moist and cavernous râles. The biliary expectoration did not contain pus or false membranes. He had never observed anything but bile with the exception of a slight amount of blood for one or two days. The urine and feces were normal. Operation was performed, the eleventh and twelfth ribs being removed. Adhesions were not present. The pleura was opened deliberately to create pneumothorax and to cause collapse of the lung. Intense dyspnea was felt in the evening. The expectoration diminished. A violent pain developed in the side, the temperature was 38.5 C (101.3 F) and profuse sweats developed. There was progressive amelioration of the symptoms on May 11. On the following day signs of general bronchitis appeared. The biliary expectoration increased progressively until it became as abundant as before operation. The wound suppurated. Blood was found in the sputum occasionally. Since the evening of June 24, blood mixed with bile had been expectorated in considerable quantities. In the morning, the expectoration was almost exclusively biliary. On July 4, he left for the country. Every day during the last days of the report he had a true hemoptysis. The

## SUMMARY

This patient was under my care and observation for more than four years. Roentgenograms taken at short intervals make up an important part of the record. The most characteristic roentgenograms are shown (figs 1, 2 and 4).

The chief factors of interest are

1 The condition was caused by indirect violence—no blow to the seat of growth but muscular exertion. Probably the stripping of the

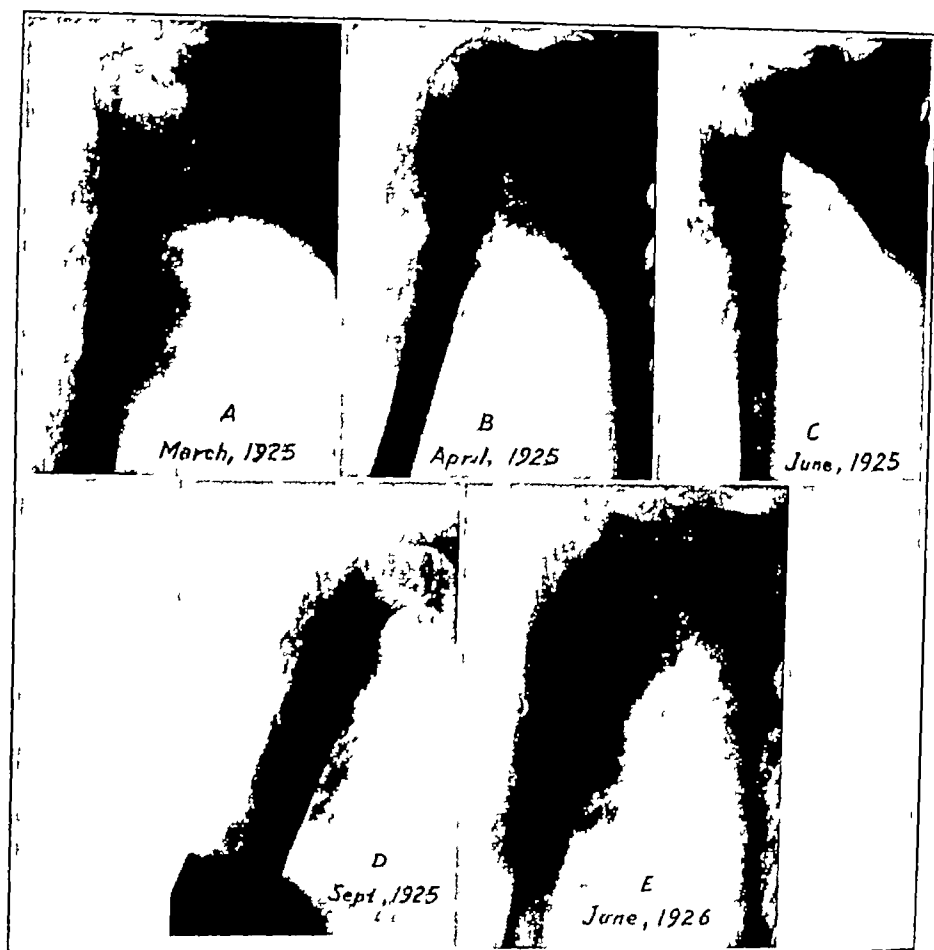


Fig 4—A, B, C, D and E show the recurrence following the first operation

periosteum and hematoma were the chief etiologic factors, the same factors encountered in a patient with myositis ossificans following backward dislocations of the elbow.

2 A steady painful growth persisted for twenty months, not showing any tendency to become stationary or to recede or a tendency to metastasis. The pain was increasing as the nerves were encroached on.

3 Recurrence occurred following removal. This is the usual history of removal before awaiting the stationary or receding stage.

1 inch in diameter and about 2 inches in length, partly extruded in the duodenum. The common duct was incised and a mass spooned out, it was cheesy, gritty, "too soft to evacuate as a whole," and weighed 2 drachms. The gallbladder was incised, and the stones were removed. The patient coughed once on being put to bed, spitting up a pellet of black bile-stained mucus. Toward morning, on April 10, about a teacupful of frothy mucopus stained a dirty brown was coughed up. The cough was troublesome, and there was some bronchitis. The patient's progress was uneventful. She was out on the sixteenth day. The sinus discharged bile for six weeks. Generally there was no expectoration during the day, but every morning she coughed for a gradually decreasing time and emptied some cavity in her lung, the amount evacuated was about a teacupful for the first few weeks, and then it lessened gradually. On June 12, 1912, the sinus had healed, the product of expectoration was reduced to about six specimens of nummular sputum each morning. Further record of the case was not made.

**SCHLESINGER'S CASE** "—A man, aged 64, entered the hospital on Jan 27, 1906. He had been healthy until 1904, then for two weeks, he had fever and severe pain in the right costal margin and shoulder and he vomited greenish fluid. Jaundice was not present. Two months later, he again had pain in the region of the liver, loss of appetite, constipation and hiccups. The attack lasted longer than a month. The urine was dark. On the right side, there was a massive dullness at the apex toward the axilla and a dullness forward on the base of the lung but not posteriorly. Friction rub could be heard over the liver. Breath sounds were diminished at the base in the area of dullness, and vocal fremitus was diminished. The skin over the dull area was edematous. Jaundice was not present. There was no bile in the urine, but urobilin was demonstrated. A puncture in the sixth interspace in the midaxillary line gave a yellow, clear exudate, containing polymorphonuclears. The patient was discharged after five weeks. From that time he coughed continuously and had pain on pressure over the margin of the right ribs. After two months, without any special previous pain, he suddenly coughed up so great a quantity of greenish colored, clear fluid that was not foul as nearly to suffocate him. This measured about half a liter. Since this time, the expectoration had been greenish and had a bitter taste. In spite of great effort, only a little sputum was raised. During the month before he was admitted to the hospital, the patient was markedly emaciated and often had fever. He was constipated.

Examination showed an emaciated man without jaundice or edema. His breathing was labored and accelerated. There was a slight even rise in temperature. Outspoken acra cyanosis was noted. The right side of the thorax lagged. The percussion note at the apex and the base of the right lung was shorter, higher and somewhat tympanitic. Dullness was present from the mamillary line axillaward in a straight line, limited by the upper edge of the sixth rib, and extended somewhat toward the scapular line. Bronchial breathing was heard in the dull area, directly over the dull area, there were numerous, medium and fine vesicular rales. Over the remaining part of the lung, especially at the right apex, isolated coarse rales were heard. Vocal fremitus was absent in the dull zone, bronchophony could not be elicited. The edge of the liver was not palpable, percussion over the liver and the dull area of the thorax was painful. A tumor was not found in the region of the liver nor was there any free fluid in the abdomen. The urine was normal. The sputum was moderately abundant, mucoid,ropy and stained a deep green-yellow, it had a stale odor and an alkaline reaction. In unstained preparation much mucus and fatty degeneration epithelial cells from the mouth were found but no neoplasm, scolices, hematoidin crystals or liver cells. Elastic tissue and other tissue were not demonstrated, and few leukocytes. There

4 In the differential diagnosis this condition could be confused with periosteal sarcoma, as it resembled it in its steady growth and failure to cease growing, the roentgenograms made prior to the first operation (*A, B, C, D, E, F* in fig 1 and *A, B, C* in fig 2) showed the cortex intact and not eroded and irregular as would be expected in sarcoma and, again, the original roentgenograms show better than the

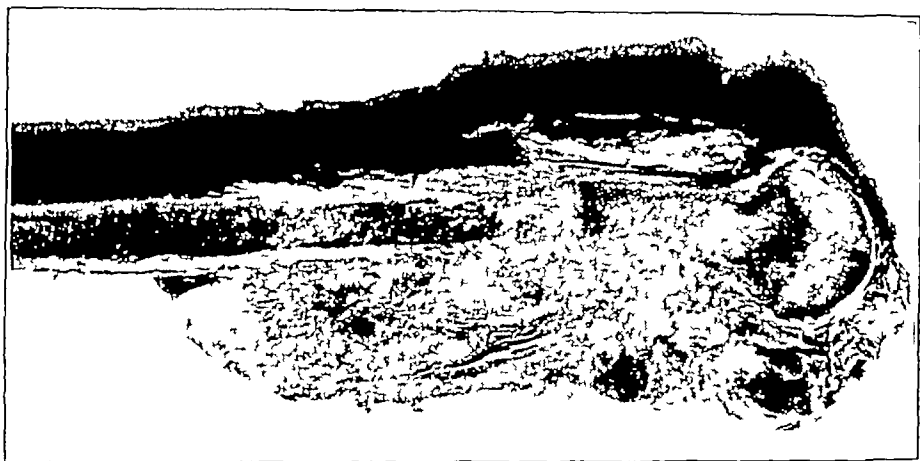


Fig 6—Laboratory specimen sawed longitudinally showing destruction of cortex

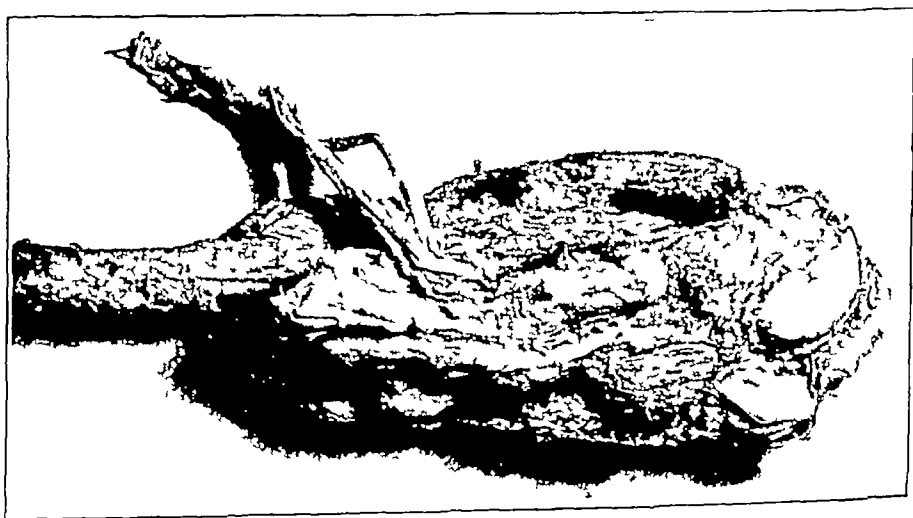


Fig 7—Appearance of growth with soft parts dissected away

reduced prints do, the shadows laid down parallel to the shaft (giving the so-called dotted veil appearance) rather than at right angles as is often noted in sarcoma

5 The first operation was performed to relieve pain and to excise a steadily growing tumor of twenty months' duration that suddenly became much more rapid in growth the second operation amputation

SCHULTZE'S CASE<sup>20</sup>—A woman, aged 25, was admitted to the hospital on Feb 6, 1873. She was generally healthy, except for minor ailments. From the middle of August, 1872, for ten weeks there had been icterus with marked pain in the region of the liver. In December, 1872, the condition had recurred, but after six weeks in the hospital she had returned to work. On Feb 3, 1873, icterus had developed. On the evening of February 5, she had had a chill followed by fever, severe headache and pain in the right hypochondrium, nausea and vomiting. Examination revealed marked icterus. The patient was doubled up with intense pain in the region of the liver and the right shoulder. The temperature was 40.7 C (105.2 F), the pulse rate, 108. Percussion in the region of the liver was scarcely tolerated. On February 7, the fever was 41 C (105.8 F). On February 8, she had herpes labialis, and the liver was enlarged. On February 10, the liver extended from the fourth right rib to the navel. Icterus was present until February 13, and then a clear reaction was not demonstrated in the urine.

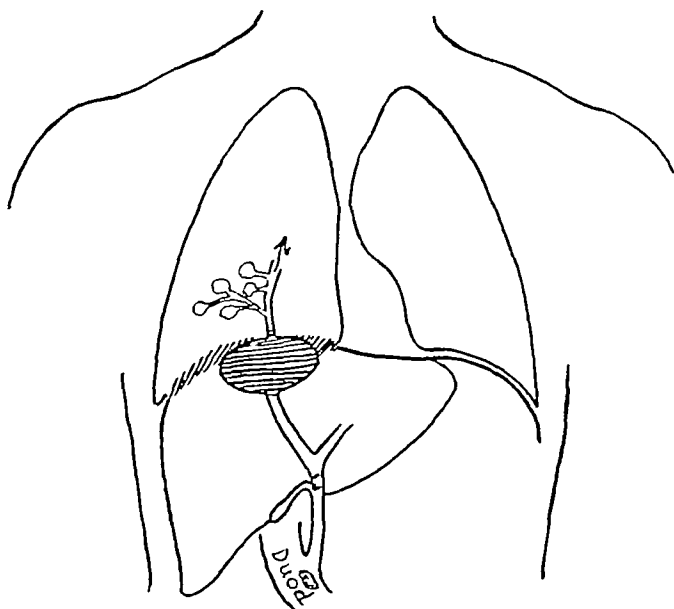


Fig 17 (Schultze's case)—Subphrenic abscess with fistula to bronchovascular cavities at the base of the lung. Stone at the junction of the cystic and common ducts.

The fever remained high after the diminution of icterus. The stools remained remarkably gray to yellow gray. Gallstones were not found. Coughing was not marked. On March 8, a scanty, slimy material mixed with a slight quantity of blood was coughed up. The lungs were normal. On March 25, after she had been nauseated for a day, had vomited once and had had a feeling of marked oppression, a large quantity of stale-smelling, but not fetid sputum was expectorated. The sputum was the color of the yolk of an egg and was coughed up in abundant quantity at various intervals. Microscopically, the yellow color was not scattered in a diffuse way through the whole mass of the sputum, but was present as smaller or larger clear yellow flecks in individual preparations. These yellow flecks disappeared when potassium hydroxide were added, and the entire preparation no longer had a uniformly yellow color. Addition of nitric acid changed the yellow to green. Partly destroyed pus cells and a great quantity of hematoidin crystals composed the great mass of sputum. There was expectoration of this



# MADUROMYCOSIS

FOURTH CASE REPORTED IN THE UNITED STATES \*

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Maduromycosis is being encountered in the United States with increasing frequency. The first case was reported by Wright<sup>1</sup> of Boston in 1898, the second by Boyd and Crutchfield<sup>2</sup> of Galveston in 1921, and the third by Gammel, Miskdjian and Thatcher<sup>3</sup> of Cleveland in 1925. The case reported here is the fourth to be reported in the United States.

Previous to 1916, this and other clinically related conditions were known in English-speaking countries as Madura foot or mycetoma. The three cases which have been reported in the United States were described under one of these names. The former name was first used by Colebrook of the Madura dispensary in India, in 1846. The latter term was originated by Carter<sup>4</sup> of London, between 1860 and 1874, who was the first to recognize the fungus nature of this group of diseases. In 1916, Chalmers and Archibald<sup>5</sup> defined mycetoma as a group name embracing the subgroups actinomycoses and the maduromycoses. The actinomycoses are familiar in America, but until recently the recognition of maduromycosis has been rare.

According to the definitions formulated by Chalmers and Archibald, the maduromycoses, although clinically similar to the actinomycoses, differ in respect to the microscopic appearance of the causative fungi. Clinically, both are chronic inflammations manifested by swellings which

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1 Wright, J. H. A Case of Mycetoma (Madura Foot). *J. Exper. Med.* **3**: 421, 1898.

2 Boyd, M. F., and Crutchfield, E. D. A Contribution to the Study of Mycetoma in North America. *Am. J. Trop. Med.* **1**: 215, 1921.

3 Gammel, J. A., Miskdjian, H., and Thatcher, H. S. Madura Foot (Mycetoma), The Black Grain Variety in a Native American. *Arch. Dermat. & Syph.* **13**: 66 (Jan.) 1926.

4 Carter, H. Vandyke. On Mycetoma or the Fungus Disease of India. London, Churchill, 1874, p. 118.

5 Chalmers, A. J., and Archibald, R. G. A Sudanese Maduromycosis. *Ann. Trop. Med. & Parasitol.* **10**: 169, 1916.

to that of a hazelnut were found in the gallbladder. It was removed and nine black, pea-sized stones were found in the common duct. Two days postoperatively, bronchitis developed. The stitches cut through during the attacks of coughing. On May 17, the temperature was falling, and the wound suppurated. On August 19, severe pain developed in the right side, the temperature in the evening was 39 C (102.2 F). Bronchitis developed in the lower lobe of the right lung, but was not striking, cough was present. The pain was localized under the right costal margin and radiated to the back, it occurred in attacks. On Jan 4, 1907, the patient entered the hospital again, still complaining of pain in the right costal margin. She brought a letter from her local physician which stated that in the beginning of April, 1907, following much coughing and severe sticking pain, she coughed up a green, biliary, bitter sputum, otherwise, her complaints were as formerly. Operation was refused. After a little time, the expectoration became white again. The condition was better until a new attack which occurred in the middle of October, 1907. The patient still refused operation. Examination revealed weak breath sounds in the right side of the back, perhaps also in front on the right side, moist coarse râles, much coughing, abundant sputum, and a small but not painful liver. In November, 1907, she coughed up sputum that varied in color from yolk yellow to yellow-brown. Microscopically, there were few erythrocytes, many white blood cells, and mucus. On November 2, she had a septic temperature and coughed in attacks which lasted several hours unless morphine was given. She expectorated a large amount of yellow and green sputum, which gave clear bile reactions and tasted bitter. The urine contained some bile. Posteriorly, the right lung was dull to the axilla, large and middle sized râles were present. The liver was not increased in size, the stool was acholic. On November 6, there was less fever and the patient was subjectively better. There was less bile in the urine, and only a trace of it in the sputum. On November 8, there was slight icterus. Posteriorly, the lower part of the right lung was dull in an area measuring 5 or 6 cm longitudinally, anteriorly, numerous sticky râles were heard, which became more audible higher up. On November 12, the temperature increased. The patient could not rest unless morphine was given. The sputum and the urine contained an increasing amount of bile. The patient was well nourished, but weak, and was annoyed by much coughing and a bile-stained, thick, purulent sputum. She suffered from severe pain in an area anterior to the axilla which extended between the eighth and eleventh ribs. Dulness was elicited over the same area and also over the lower lobe of the right lungs, bronchial breathing and râles were heard. On November 16, the seventh and eighth ribs were resected in the anterior axillary line. The lung was adherent in front to the axilla and the diaphragm, but was free posteriorly. The liver appeared to be adherent below, this was confirmed by incision of the liver. The cavity in the lung contained a foul-smelling, bile-stained abscess the size of a hen's egg, and a cavity about the size of a walnut was found in the liver. It emptied itself of a few yellow-brown tissue hulls resembling echinococci. In the depth of the cavity, there was a three-branched communication with a bronchus. A tampon was employed. Fever and jaundice developed the day after operation. The membrane was removed. Echinococcosis was diagnosed as microscopic examination revealed an echinococcic wall. On November 27, slow healing began, the expectoration became less, and was white. The wound of the previous operation was again opened widely on December 20. The bronchus opening was still easy to find, but no longer communicated with the liver. The cavity communicating with the bronchi was lined with epithelium. Energetic treatment was instituted with Paquelin's cautery, this was also applied to the surface of the lung



Fig 1 —Dorsal view of foot in case of maduromycosis

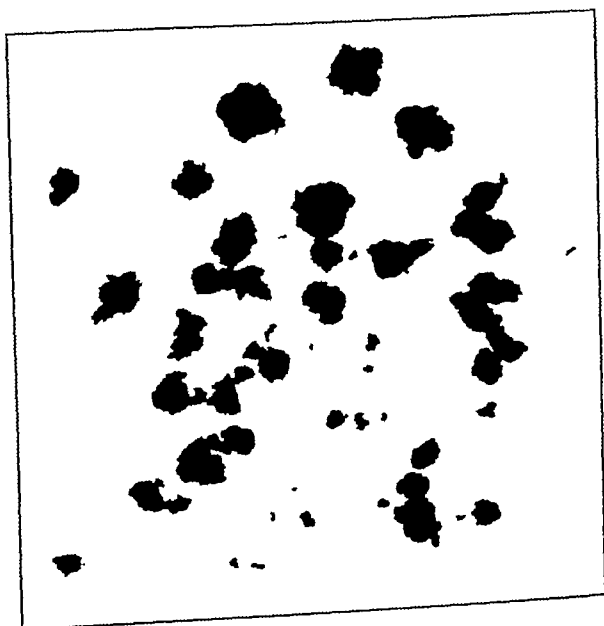


Fig 2 —Washed brown granules from case of maduromycosis

that the local tenderness had increased. There was no change in the thorax. The patient remained the same until January 17, when the stools became pale, but not definitely clay-colored. The urine also showed a trace of bile. On January 21, the stools were clay-colored, the cough was the same, but increased when the patient lay down. When she lay on the left side, she coughed up more fluid. There was tenderness at the right costal margin. On February 4, there was no bile in the urine, the stools were only slightly paler than normal. The skin was slightly yellow, and the conjunctivae were definitely icteric. The amount of sputum was the same. On February 7, epigastric pain and clay-colored stools appeared. On February 17, operation was performed, and the adhesions of the gallbladder to the colon were released. The gallbladder was empty and contracted, the walls were thickened and fibrous. The cystic duct was slightly dilated, the common duct was the size of the forefinger. Calculi were found low down in the common duct behind the head of the pancreas. The common duct was opened and the two calculi were removed. Drainage was instituted through the gallbladder. The calculi were faceted, the larger one being the size of a marble, the smaller one, the size of a hazelnut. On February 18, she vomited bile-stained fluid and blood. The cough had almost ceased, so that the patient could lay on her back without much discomfort. She still coughed up mucus and bright green bile occasionally. On February 20, there was still a slight amount of bile-stained sputum. On February 21, her cough had almost entirely disappeared. There was little sputum, and it did not contain a trace of bile. By February 23, there was practically no cough. A fecal fistula opened. One month after the operation, she was sitting up, a slight amount of bile still discharged about the wound, the fecal fistula was closed. Later record showed that the wound healed entirely.

SMITTEN'S CASE <sup>10</sup>—A woman, aged 23, complained of weakness, loss of appetite and cough, which became worse when lying on the right side. Illness had begun two and one half months previously with a cough. Three weeks before admission to the hospital her temperature had risen to 38 and 40 C (100.4 and 104 F), and remained high for eight days. A purulent-like fluid had been expelled on the third day, it had been yellow. On admission to the hospital, the temperature was 36.2 C (97.1 F). Percussion below the scapula on the right side was dull, the note was tympanic around the area of dullness. The greatest tympanic note was obtained between the scapula and the posterior axillary line. There was bronchial breathing here and above the scapula. A pleural rub was heard on the left side in front to the axillary line. The heart was two fingerbreadths to the left of the nipple line. The patient had to assume a sitting position night and day to save herself from choking. She could not lie on the right side. The author believed that she had a chronic subdiaphragmatic abscess which was responsible for the passage between the bronchus and one of the larger biliary ducts, and explained the total absence of bile in the intestine by inflammatory disease, he therefore decided to remove the obstruction to the passage of bile, taking the route through the abdomen. Under local anesthesia, an incision was made parallel to the costal margin. Normal bile ducts were found, but no adhesions. The incision was closed, and transpleural laparotomy was performed by resection of two ribs with exposure of the pleural cavity. The liver was held to the diaphragm by massive adhesions. The patient did not bear operation well because of cardiac trouble, and the procedure was discontinued. She died later. At autopsy the diaphragm was found cemented to the lower lobe of the right lung. A cavity, 5 by 5 cm was found in the adhesions. A passage through the parenchyma of liver to one of the biliary passages was found also a passage to one of the bronchi. The main bile duct was free from bile. There was diffuse bronchitis in the lung.

zone of soft granulations and a narrow outer zone of yellow tissue. The remainder of the tumor was fibrous tissue. On removal of the granules, abscess cavities with intercommunicating fistulas were exposed.

In microscopic sections, irregular islands of golden brown granules were seen some loose within abscess cavities (fig 6), others closely enveloped in granulation and fibrous tissue. The granules corresponded with the descriptions of Wright. They were composed of brown, hyaline-like reticulum and amorphous pigmented material. The peripheries of some of the granules were composed of narrow zones of yellow, hyaline, refractile, actively proliferating mycelia (fig 7). There were



Fig 7—Margin of granule, striated zone of proliferating mycelia is shown

granules the mycelial filaments of which infiltrated the surrounding tissue and others were surrounded by dense fibrous tissue which apparently restricted the growth of the fungus. In the majority of instances, the granules were separated from the surrounding tissue by narrow zones containing few inflammatory cells or broad zones with many cells constituting abscesses.

Mononuclear cells of the plasma cell type predominated and infiltrated the granulation tissue freely. The more remote tissues were markedly edematous and contained not only the cellular infiltrates in large numbers, but also actively proliferating young fibroblasts and new capillaries as apparent by the presence of actively proliferating endothelial cells. Foam cells or xanthoma cells with faintly stained abundant cytoplasm and relatively small nuclei were present in clusters, particularly in the peripheries of abscesses (fig 8). Giant cells, which are

Examination did not show anything remarkable. Two days later, she had a violent attack during the night accompanied by severe pain and retching. On January 25, there was a recurrence of the violent attack. Stones in the cystic duct was diagnosed. Her condition remained the same for three weeks, she vomited frequently and had pain between the shoulder blades. On February 18, severe chill and hepatic dulness,  $1\frac{1}{2}$  inches below the costal margin in the mammary line were noted. There was an area of tenderness on pressure over the right hypochondrium. On February 23, the patient had two attacks of chills and retched violently. On February 25, the pulse was feeble and the rate was 130. The pain in the back had become less severe and was localized to the right hypochondrium. On February 27, she had fits of coughing accompanied by expectoration of small purulent masses with a brownish tinge and a fetid smell. Resonance at the base of the right lung was impaired and friction sounds were heard on deep inspiration. On February 28, she coughed up a few ounces of brownish substance

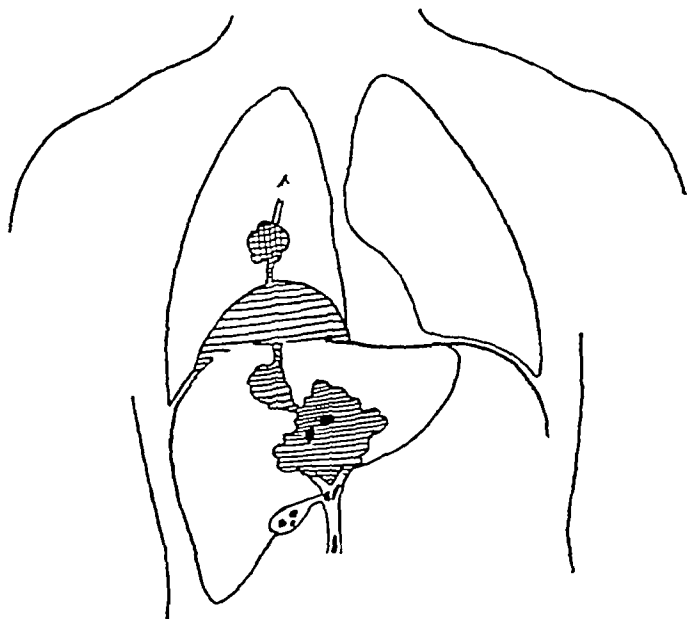


Fig 19 (Tuckwell's case) —Large abscess cavities in the liver and subphrenic space, common duct blocked by stones, cavity on the lung, double hour glass type of fistula

with a fetid odor. Her breath was fetid (gangrene lung?). Dulness increased on the right side, posteriorly, and bronchial breathing was heard. On March 2 she coughed up more foul-smelling material. Her condition was becoming progressively worse. The dulness now reached the scapula and sounds below were absent. She continued to bring up small quantities of sputum daily, never more than a few ounces of the same, foul-smelling brown expectoration, until March 4, when the eyes and skin were jaundiced for the first time. On March 6 the patient was deeply jaundiced. Death resulted. Postmortem examination revealed the gallbladder enlarged to twice its natural size. The right lung was compressed and pushed up by from 40 to 50 ounces of fetid pus in the pleura. One patch the size of a small apple in the lower lobe was gangrenous. The upper and posterior part of the liver was adherent to the diaphragm. The interior of the right lobe of the liver was converted into a large irregular cavity crossed by a partition of broken-down hepatic tissue surrounded by ragged walls. The cavity was filled with foul pus and contained several small biliary concretions and it

in saccharose and lactose broth (fig 10) Not pathogenic for rabbits or guinea-pigs Isolated by Ikeda from a maduromycosis with black grains, in Minneapolis

Gammel made the following statement concerning the identity of this organism

The complete life history of this organism is not known and as it reproduces by spores which are not contained in asci or basidia it must be placed in Fuckel's class "Fungi imperfecti" or "Hyphomycetes" As no accessory organs of fruc-

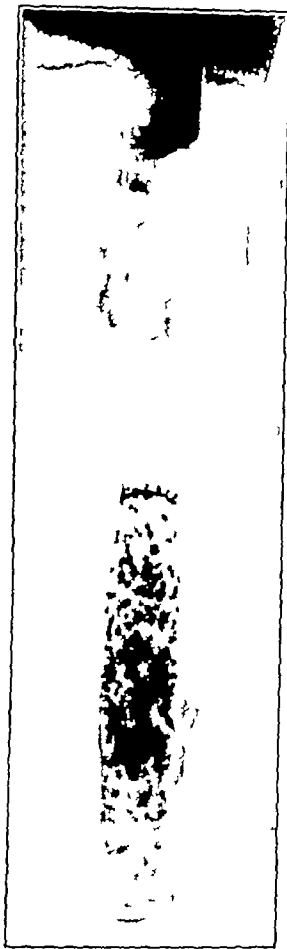


Fig 9—Sclerotia numerous on surface and in depths of Sabouraud's preservative medium

tification can be seen and as reproduction seems to be by means of spores situated on hyphae they belong to Vuillemin's subclass "Hyphales" As the spores are formed by fragmentation of the thallus it must be placed in the order "Thallosporales," suborder "Arthrosporineae," both defined by Vuillemin in 1910 This suborder contains two genera isolated from maduromycoses, namely, genus "Madurella," Brumpt, 1905, and genus "Indiella," Brumpt, 1905

It is apparent that this organism belongs to the genus "Madurella," Brumpt, 1905, emendavit Pinoy, 1912 On comparison with the characteristics of other species of "Madurella," insofar as available from the literature, the fungus seems to be an undescribed species at least at the present state of knowledge, and the

had pain in the back for seven years, the onset being about her twentieth year, in 1883, when she had a large liver and a bulging on the right side of the thorax. Puncture of the liver had released a clear fluid and echinococcic hooklets had been demonstrated. Within the next two years, she had had two attacks of sickness resembling attacks of acute cholangitis. Echinococcic cysts were found in the stools, they were found once while the patient was in the hospital. The enlarged liver slowly returned to normal. In June, 1885, thrombosis of the right and left femoral veins had developed. The patient had not been seriously sick since 1885 and did not have pain in the back. On entry to the hospital, she was weak and thin, her temperature was subnormal with sharp rises. The dulness in lung gradually increased. Albumin was found in the urine but no bile pigments nor urobilin. There were no clay-colored stools nor blood. Several examinations of the sputum did not reveal tuberculosis nor echinococcus. The daily output of sputum was between 50 and 600 Gm, it was markedly bile-colored and rarely did

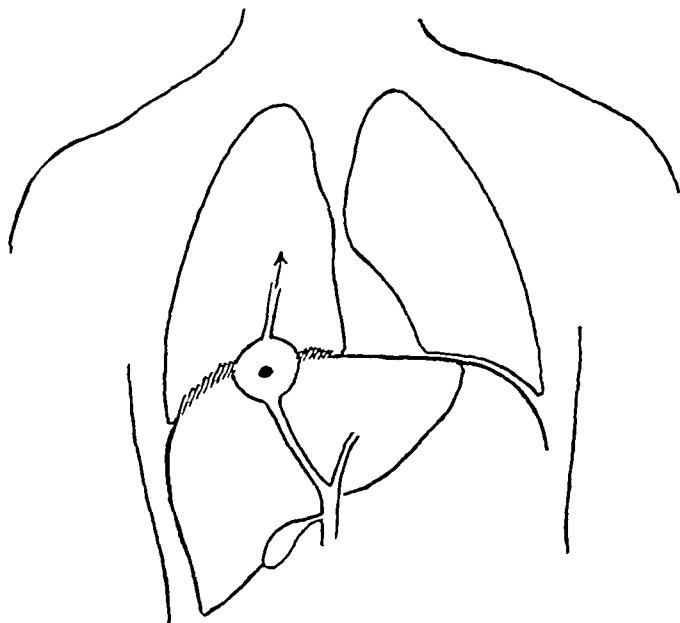


Fig 20 (Van Wijhe and Hammer's case) —Subphrenic abscess with ball valve stone and fistula

not contain bile. The complement-fixation test (Weinberg's method) was negative. A roentgenogram showed a "spongy" shadow in the right lobe of the liver as large as a Gulden. Because of weakness and dragging down by the expectoration of bile, it was decided to operate. On Sept 19, 1921, the right lobe of the liver was exposed across the right pleural cavity. In separating the adhesions, a calculus was found in this region. This was partially removed and the cavity was tamponed with gauze. The patient did not survive the night. Postmortem examination revealed a cavity, part of which was in the liver and part above, lying somewhere to the right of the midline, bile passages connected with it and appearing like main branches of the hepatic duct, a fistula to the main bronchus of the lower lobe of the right lung and thick adhesions in the right side of the liver, the sternum and the right lung.

**VISSERING'S CASE.**<sup>20</sup>—A man, aged 63, was admitted to the hospital on July 19, 1895, complaining of pressure in the region of the stomach, loss of appetite and constipation for two days. The next evening, he had an intense chill and severe



# THE PRESENT STATUS OF MYCETOMA

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The term mycetoma is used at the present time to include maduromycosis and actinomycosis. In 1846, before the causes of these chronic inflammatory conditions were known, Colebrook<sup>1</sup> first recorded in the literature the geographico-anatomic name, Madura foot. Carter,<sup>2</sup> in his monograph published in 1874, designated them on the basis of etiology and pathology by the term mycetoma (meaning fungus tumor). The term maduromycosis was introduced in 1916 by Chalmers and Archibald<sup>3</sup> to apply to an etiologic subgroup of mycetoma, which they distinguish from actinomycosis. Actinomycosis, as caused by *Actinomyces bovis*, has been known since the work of Bollinger in 1878, and as many of the organisms isolated from cases of Madura foot or mycetoma of the foot have been found to belong to the genus *Actinomyces*, actinomycosis likewise has become a subgroup of the mycetomas. Although progress has been made during the last decade in respect to the etiologic and mycologic classification of mycetoma, much confusion still exists in the literature, from botanic considerations involved, which has tended to obscure the clinical and pathologic aspects of the mycetomas, as well as the fact that as yet no differentiation on a clinical or pathologic basis can be made of the varieties of mycetoma. It is necessary, therefore in any such consideration of these diseases, to retain the term mycetoma as the name of the group.

Twenty-one cases of mycetoma have been reported from the United States. After a critical study of these cases, Gammel<sup>4</sup> concluded that according to Chalmers and Archibald's criteria, most of them were cases of actinomycosis and that only three were cases of maduromycosis.

It is my purpose in this paper, in contrast to that of most recent writers, to present a consideration of the mycetomas from a clinical rather than from an etiologic standpoint. It was my privilege to encounter the fourth case of maduromycosis in the United States which was the first case to be reported as such.<sup>5</sup>

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1 Chalmers, A J, and Christopherson, J B. A Sudanese Actinomycosis, *Ann Trop Med & Parasitol* **10** 223, 1916

2 Carter, H Vandyke. On Mycetoma or the Fungus Disease of India. London, Churchill, 1874, p 118

3 Chalmers, A J, and Archibald, R G. A Sudanese Maduromycosis, *Ann Trop Med & Parasitol* **10** 169, 1916

4 Gammel, J A. The Etiology of Maduromycosis with a Mycologic Report of Two New Species Observed in the United States, *Arch Dermat & Syph* **15** 241 (March) 1927

5 Thompson, H L, and Ikeda, Kano. Maduromycosis. Fourth Case Reported in the United States, *Arch Surg* (In press)

lost her appetite and had had fever. She had not had chills, but a burning and piercing pain had been present in right costal margin, in the back and in the right arm. The pain had increased. On April 19, the pain had been severe and continuous. Since then she had suffered from nausea and regurgitation of a bitter tasting, greenish, slimy material. She complained of shortness of breath and of a "sticking" pain in the right side. Examination revealed nothing remarkable except dulness in lower part of the right side of the chest. Puncture in the eighth and ninth interspace of the posterior axillary line was performed without result. On April 28, pleurisy developed in the right side. On May 9, a sudden sharp pain was felt in the right side and there was cough with expectoration, there was slight collapse. The sputum was slimy, uniform and abundant, with opaque, yellow yolklike specks. Microscopic examination revealed fatty degeneration pus cells, numerous bilirubin crystals and no elastic tissue. On May 10, the patient was pulseless, in a state of marked collapse and vomited. Death occurred at 7:30 p. m. Postmortem examination revealed a right-sided purulent pleurisy and compression of the lung. There was a subphrenic abscess in the right side of the liver. The base of the lung and surface of the liver adhered to the diaphragm. At the highest place in the diaphragm there was a perforation into the parenchyma of the lung. An old atrophic cholecystitis and cholelithiasis of the gallbladder, cystic and common duct were noted. A fistula of the common duct led to the region of the papilla duodenum. There was a duodenal polyp at this place.

YATES' CASE<sup>22</sup>—A man, aged 47, in June, 1921, complained of loss of weight and a feeling of general weakness and illness. A few days later, a severe hiccup commenced, which lasted for nine days and then ceased abruptly. It was so severe that it deprived the patient of sleep and seriously interfered with eating and even with speaking. When it disappeared the only complaint was general weakness. Three weeks later, however, a cough began, accompanied by copious expectoration, which he described as being "like brown jelly and sometimes streaked with blood." This continued for one month, when the color of the sputum suddenly changed to yellow. It was now intensely irritating and associated with violent paroxysmal cough which sometimes led to vomiting. He was admitted to the hospital on November 5. He had had scarlet fever at 8 and pneumonia at 16, and gonorrhea at 19. He had never been abroad, and had not had dysentery. He was coughing up large quantities of clear, bright yellow fluid which consisted almost entirely of bile and contained a few gram-positive cocci and one or two cells, but no pus. There were no traces of amebas or hooklets. He was emaciated and weighed 102½ pounds (46.6 Kg). Before his illness, his weight was 128 pounds (58.1 Kg). He was not jaundiced. There was a small area of impaired breathing at the base of the right lung, over which medium crepitant rales could be heard. The breath sounds over this area were harsh and vesicular. Vocal fremitus and vocal resonance were not changed. The liver was a little enlarged, and it could be felt just below the costal margin, somewhat rounded and hard. There were several dilated veins in the abdominal wall chiefly on the right side above and below the umbilicus. Operation was performed on November 25, and portions of the eighth and ninth rib on the right side were resected, the upper surface of the diaphragm was explored. No opening was seen. The adherent surfaces were separated as completely as possible, and a drainage tube was inserted from which a small amount of bile escaped for a few days. After operation, the coughing up of bile ceased completely for five days and then began again. The patient continued to raise a considerable quantity for some time but it steadily decreased.

This is the accepted use of the term at the present time

The mycetomas were divided by Chalmers and Archibald into two groups (a) the maduromycoses, and (b) the actinomycoses. These terms also were defined by them as follows

The maduromycoses are the forms of mycetoma with grains composed of large segmented mycelial filaments possessing well-defined walls and usually chlamydospores

The actinomycoses are those forms of mycetoma with grains composed of very fine nonsegmented mycelial filaments, the walls of which are not clearly defined from the contents and in which chlamydospores are absent

In order to avoid further confusion of the term grain with the non-specific term granule, and with the mycologic expression sclerotium the former term also was defined

The word grain is applied to certain bodies found in mycetomas of varying color, consistence, size and shape, which are composed of hyphae, and sometimes chlamydospores, imbedded in a matrix and which on germination give rise to mycelial filaments

The term grain thus has become a specific term for the bodies found in the tissues and discharges of the mycetomas as the word tubercle is for the pathologic unit of tuberculosis

Chalmers and Archibald contributed much to the elucidation of the subject of mycetoma, although considerable confusion continues to exist

#### HISTORY

In an attempt to clarify the confusion in the literature on the mycetomas of up to a decade ago, Chalmers and Christopherson employed the helpful method of dividing their discussion of the evolution of the knowledge of this group of diseases into four historic periods. When possible, they designated each period by the most significant name for the diseases extant during that period. With the same object in mind, I wish to modify the name of their fourth period and add a fifth period to their list. This modification of their plan is as follows: (1) The early period (—1846), (2) the Madura foot period (1846-1860), (3) the mycetoma period (1860-1878), (4) the mycetoma-actinomycosis period (1878-1913), and (5) the mycetomas period (1913- ). My fifth period dates from the extension of the term mycetoma from its original conception as one disease to its present status as a group name for several similar diseases.

The early period is characterized by an attempt to establish the first record of cases in this group of pathologic conditions. According to Chalmers and Christopherson, the various types of mycetoma of the foot were distinguished from elephantiasis and possibly from yaws by the early Indian surgeons provided Waring's reference to Sanscrit

# MYOSITIS OSSIFICANS

A STUDY OF ANOTHER UNUSUAL CASE \*

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My only excuse for reporting the following case of myositis ossificans is that failed to follow the usual course of this long recognized condition, and also because of several interesting points in the differential diagnosis.

In 1925, Adam Gruca<sup>1</sup> published a clinical and experimental study of this condition, with a detailed report of seventeen cases. He gives what I believe is the best classification to date. It is as follows:

- 1 Myositis Ossificans Traumatica
  - (a) Following a severe single injury by blunt force
  - (b) Following dislocations, i. e., elbow, clavicle, knee, shoulder
  - (c) Development of bone along the track of perforating gunshot wounds
  - (d) After clean incised wounds
- 2 Myositis Ossificans Chronica
  - (a) After repeated slight trauma i. e., rider's bone, soldier's shoulder
  - (b) Occupational
  - (c) Nontraumatic, history of trauma not obtainable
- 3 Myositis Ossificans of Infectious Origin
- 4 Myositis Ossificans—Para-Arthritica
- 5 Myositis Ossificans—Neurotica

In his article he also groups the numerous theories into two divisions. Those assuming that parosteal bone arises from the periosteum of the neighboring bone, and those attributing the condition to a metaplasia of local connective tissue.

Unfortunately, however, up to the present it has been impossible to prove these various theories experimentally, and until myositis ossificans can be experimentally produced, my case revealing new departures from the usual should be reported, as it is on clinical observations that one has to rely to solve the problem. Therefore, I am reporting the following case:

## REPORT OF CASE

*Present Illness.*—J. S., an upholsterer, aged 28, was married and had two children. The family history was negative.

On March 9, 1923, while helping to lift an automobile from the mud, the patient felt a sharp, sudden pain in the upper portion of his right arm and shoulder. The following day his arm was tender, as was his shoulder, and the muscles of the

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1. Gruca, A. Myositis Ossificans Circumscripta. *Ann. Surg.* 82: 883, 1925.

the fungus of mycetoma to that of actinomycosis. This period somewhat overlaps the succeeding period wherein the nature of certain types of actinomycosis became established.

During the actinomycosis-mycetoma period, from 1878 to 1913, little real progress was reported, and the knowledge that was contributed was obscured by lack of uniformity in nomenclature. The period dates from the work of Bollinger,<sup>1</sup> the results of which were published in 1876, on lumpy jaw of cattle, in which a branching fungus was constantly observed. The organism was studied by Hartz<sup>1</sup> who gave it the name *Actinomyces bovis* (1877). As pointed out by Gammel, the British object to the use of this name and apply the generic name *Nocardia* after the French pathologist Nocard, on the authority of the First International Congress of Pathology. The French, on the other hand, call the genus *Discomyces*, but the Germans and Americans continue to call it *Actinomyces*, the latter accepting the authority of the Society of American Bacteriologists. Many other generic names have been suggested by investigators of organisms from isolated cases. Many of the organisms with different names have been found to be identical and accordingly have been reclassified under one or the other group.

It was during this period that Carter<sup>3</sup> abandoned his contention that *Chimomyces carteri* was the cause of mycetoma. In 1893, Kanthack<sup>11</sup> studied both yellow and black mycetomas, concluded that the yellow variety was actinomycosis, and, in direct opposition to Carter's earlier view, held that the black was a degenerative stage of the yellow. Unna<sup>3</sup> examined Kanthack's specimens and found many distinctions between the fungi of the two varieties. Finally, in 1894, Boyce and Surveyor<sup>12</sup> established definitely the existence of different organisms in black and yellow types of mycetoma of the foot.

In 1894, Vincent,<sup>1</sup> in Algiers, isolated from a mycetoma with yellow grains an organism which he called *Streptothrix maduræ*. Notwithstanding the fact that this generic name had been used previously for an entirely different organism, the term continues to appear in the literature as a synonym for *Hyphomycetes* or *Actinomyces*, only to further the confusion already existing.

Toward the close of this period distinct progress was made by a few workers in the identification and classification of the fungi isolated from the granules taken from cases of this peculiar group of diseases.

The mycetomas period dates from 1913, when Pinoy proposed to extend the term mycetoma to include actinomycoses, caused by *Actino-*

11 Kanthack, A. A. Madura Disease (Mycetoma) and Actinomycosis, J. Path. & Bacteriol. 1 140, 1893.

12 Boyce, R., and Surveyor, N. F. Upon the Existence of More Than One Fungus in Madura Foot (Mycetoma) Phil. Tr. Roy. Soc. London 185 1 1895.

The patient was advised to stop work, apply hot applications to his shoulder, keep his arm in a sling and, notwithstanding a negative Wassermann reaction, he was given 45 grains (2.6 Gm.) of potassium iodide a day. The patient remained away from his work two months and then returned to his usual occupation because of economic reasons.

He reported to me again in October, 1923, on account of pain and increase in the size of the mass. At this time, seven months from the date of injury, the mass was larger, felt bony and seemed to be extending around the shaft of the humerus. It was firmly attached to the shaft along the outer side, and the tips of the examining fingers could dip under the mass on the posterior and inner side of the

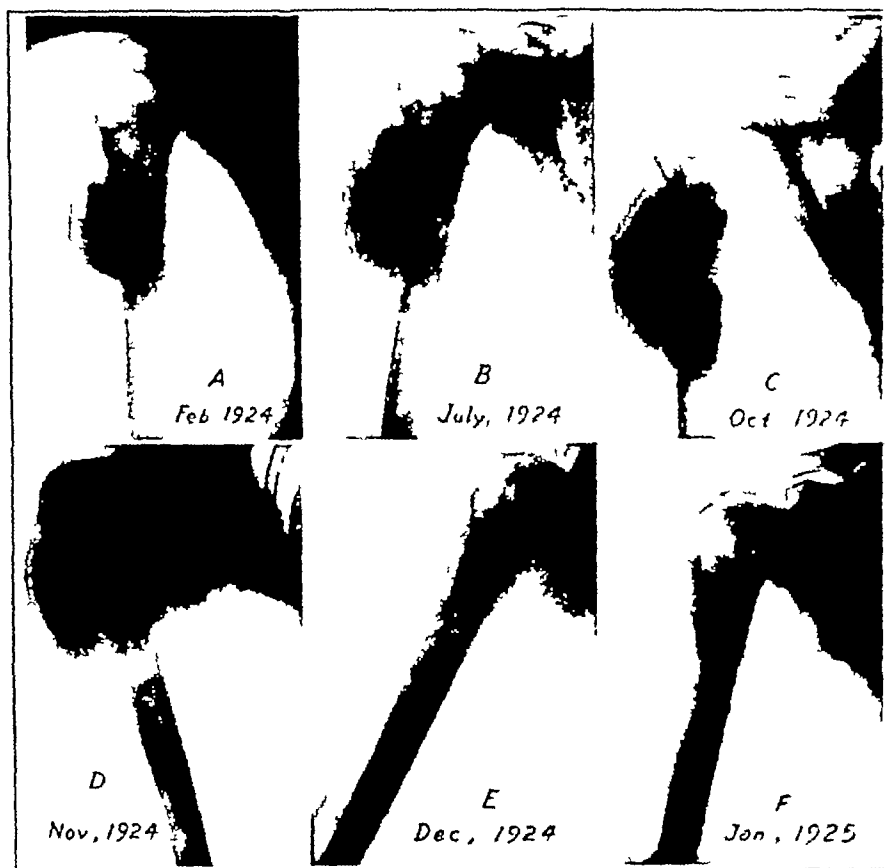


Fig 2—*A B and C* show the increasing size of the tumor. *D E and F* show the appearance following the first operation.

arm. It felt like a pedunculated bony tumor attached to the humerus at one point. The diagnosis at this time was myositis ossificans, and operation was strongly considered chiefly on account of the increasing pain and also because the mass was steadily increasing in size and growing around the shaft toward the chief blood and nerve supply of the extremity.

The patient was seen by the surgical staff of the Johns Hopkins Hospital, and there was a marked difference of opinion as to the advisability of operating during this actively growing stage. It was decided to await the cessation of growth before operation unless the pain element or the blockage to the circulation forced surgical steps.

## ETIOLOGY

The mycetomas are widely distributed throughout tropical and sub-tropical zones. They are endemic in certain districts in India and are seen occasionally in Africa, Europe, South America, Mexico and the United States. In this country twenty-two cases<sup>1</sup> have been reported previously, including one each from Indiana, Iowa, Massachusetts, Maryland, and Minnesota, two from Arizona, three from California, and the remainder from Texas.

On the basis of an analysis of 100 cases of mycetoma, the majority of which were said to be maduromycoses, Bocarro<sup>17</sup> of Hyderabad in 1893, pointed out the chief factors which predisposed to these fungous infections. Ninety-two of the patients were males and eight females. The patients were from 12 to 80 years of age, most of them being between 21 and 40. All of the patients were rural inhabitants, and ninety-one tilled the soil. Seven of the eight female patients were wives of agriculturists. The foot was the site of the disease in ninety-three cases, the leg in two, the hand in three, and the trunk in two. Carter emphasized the fact that none of his patients with mycetoma had ever worn shoes and that most of them attributed the origin of the disease to trauma of the barefoot and many specifically to thorn pricks. Boyd and Crutchfield, in an analysis of the cases which occurred in North America, corroborate the observations of Bocarro and Carter.

The mode of inoculation is not known. In view of the fact that a history of trauma is obtainable in about one half of the cases, it is presumable that the fungus enters through an open wound. The hair follicles and the ducts of the glands of the skin also have been suggested as points of entrance. The mycetomas are most common, therefore, in tropical and subtropical zones, among men between the ages of 20 and 40 who till the soil and who have received an injury to the bare foot.

A characteristic of the mycetomas is the presence in the tissues and discharges of granules or grains which contain the causative fungus. The several colors of grains were noted by Carter, who employed this feature as the basis for the earliest classification of the mycetomas. He distinguished the yellow or ochroid, the black or melanoid and the red varieties. Within the last two decades, added knowledge of the fungi which produce the mycetomas has permitted the formulation of the other classifications on a mycologic basis. Thus under the group name mycetoma Pinoy included the actinomycoses and the true mycetoma. Brumpt included the actinomycotic mycetoma and the true mycetoma and Chalmers and Archibald included the actinomycoses and the maduromycoses.

<sup>17</sup> Bocarro J. E. An Analysis of One Hundred Cases of Mycetoma. *Lancet* 2: 797, 1893.

The increase in the size of the tumor was checked by the roentgen ray every five or six weeks (*A, B, C, D, E, F* in fig 1 and *A, B, C* in fig 2). The pain was controlled by codeine and the patient allowed to continue his regular work.

Starting about September, 1924 the mass which had been growing fairly slowly, started a rapid growth and increased as much as 4 cm in diameter in four weeks, and only a small channel on the inner side of the arm kept the mass from completely surrounding the shaft. Pain was more severe and could not be controlled by codeine. This sudden rapid increase in size made us decide to operate and operation was done at the Church Home and Infirmary on Oct. 23, 1924, twenty months after injury.

*First Operation*—Under ether anesthesia a large horseshoe-shaped flap of skin was turned up, and a large cartilaginous bonelike mass was exposed, it was reddish-gray and was not encapsulated. There was no line of cleavage, and overlying muscles had to be separated from the growth by sharp dissection. The mass was curetted down to the shaft to which it was intimately connected and which it surrounded, except the groove in which the vessels passed. A good deal of periosteum and some cortex was curetted and chiseled off. The musculospiral nerve was running through the tumor and was knicked badly during the process of separation, but it was sutured at once. The wound was closed, and a firm bandage applied. The wound healed without any complications by December 1. Sections (fig 3) were made and studied at the Church Home and Infirmary and in Dr. Bloodgood's laboratory at Johns Hopkins Hospital and also by Dr. D. B. Phemister, in Chicago. In none of the numerous sections studied were any signs of malignant disease noted. The sections showed an irregular mixture of bone, cartilage, muscle and connective tissue. In this case the newly formed bone was less orderly than in most cases reported. The trabeculae were blotchy, and the tissue filling the cancellous spaces of the new bone and about its margins were rich in spindle cells.

Following operation the patient was free from pain and it was hoped that a cure had been obtained. By January, 1925, two months after operation some hardness of muscle could be detected clinically and could be definitely seen in roentgenograms taken about this time (*I* in fig 2 and *I* in fig 4) and we realized that a recurrence had started. The patient developed complete wrist drop in March, 1925, at which time he was referred to Dr. William Neal (Dr. Kelly's Hospital) for radium therapy. The wrist drop cleared up promptly, but I do not believe this was the result of the radium. The growth increased steadily (*B, C* and *D* in fig 4) and was extending upward toward the shoulder joint. By September, 1925, the shoulder joint was nearly completely ankylosed, the motions of the elbow, wrist and fingers remained normal, and the patient was practically free from pain. The mass continued to become steadily larger (*L* in fig 4) and as the blood and nerve supply to the arm were again threatened, amputation was advised. A roentgenogram of the chest did not show growth.

*Second Operation*—At the Church Home and Infirmary, July 14, 1926, under ether anesthesia, amputation of the shoulder joint was performed by first sawing through the clavicle, ligating the subclavian vessels in the neck, and then injecting 1 per cent procaine hydrochloride into the brachial plexus. The wound healed without complications and very little postoperative pain was present. Sections showed (fig 5) typical myositis ossificans and not any evidence of a malignant condition.

I saw and examined the patient in November, 1927, one and one half years after amputation and there was no evidence of any further involvement. The patient both looked and said that he felt fine. He weighed 158 pounds (71.7 Kg.) a gain of 18 pounds (8.2 Kg.) since the date he was first seen.



isolated in cases of maduromycosis each of which produced the clinical picture of mycetoma of the foot. The following list of organisms was taken from this report

### Organisms isolated in cases of actinomycosis

#### I Class Schizomycetes

##### A Genus Actinomyces

- 1 *Actinomyces bovis*, Harz, 1877
- 2 *Actinomyces mexicanus*, Boyd and Crutchfield, 1921
- 3 *Actinomyces asteroides*, Eppinger, 1890
- 4 *Actinomyces bahiensis*, Piraja da Silva, 1919
- 5 *Actinomyces convolutus*, Chalmers and Christopherson, 1916
- 6 *Actinomyces indicus*, Kanthack, 1893
- 7 *Actinomyces madurac*, H. Vincent, 1894
- 8 *Actinomyces somaliensis*, Brumpt, 1906
- 9 *Actinomyces sp.*, Yazbek, 1920 (Seems closely related to *Actinomyces somaliensis*)
- 10 *Actinomyces sp.*, Yazbek, 1920 (Related to *Actinomyces asteroides*)
- 11 *Actinomyces pelletieri*, Laveran, 1906
- 12 *Actinomyces verrucosus*, Miescher, 1916
- 13 *Actinomyces ponceti*, Verdun, 1912

### Organisms isolated in cases of maduromycosis

#### I Class Fungi imperfecti

##### A Genus Madurella

- 1 *Madurella mycetomi*, Laveran, 1902
- 2 *Madurella bovoi*, Brumpt, 1910
- 3 *Madurella oswaldoi*, Parreiras Horta, 1919
- 4 *Madurella ramiroi*, Piraja da Silva, 1919
- 5 *Madurella tabarcae*, Blanc and Brun, 1919
- 6 *Madurella tozeuri*, Nicolle and Pinoy, 1908
- 7 *Madurella americana*, Gammel, 1925
- 8 *Madurella ikedai*, Gammel, 1926

##### B Genus Indiella

- 1 *Indiella mansonii*, Brumpt, 1906
- 2 *Indiella reymeri*, Brumpt, 1906
- 3 *Indiella brumpti*, Piraja da Silva, 1922

##### C Genus Glenospora

- 1 *Glenospora lhartoumensis*, Chalmers and Archibald, 1916
- 2 *Glenospora semoni*, Chalmers and Archibald, 1917

##### D Genus Scedosporium

- 1 *Scedosporium apiospermum*, Saccardo, 1911
- 2 *Scedosporium sclerotiale* (seu nigricans), Pepere, 1914

#### II Class Ascomycetes

##### A Genus Allescheria

- 1 *Allescheria boydii*, Shear, 1921

##### B Genus Aspergillus

- 1 *Aspergillus buoffardi*, Brumpt, 1906

##### C Genus Sterigmatocystis

- 1 *Sterigmatocystis* (*Diplostephanus*) *indulans*, Eidam, 1883, variety Nicollet, 1906

##### D Genus Penicillium

- 1 *Penicillium mycetogenum*, Mantelli and Nigri, 1915

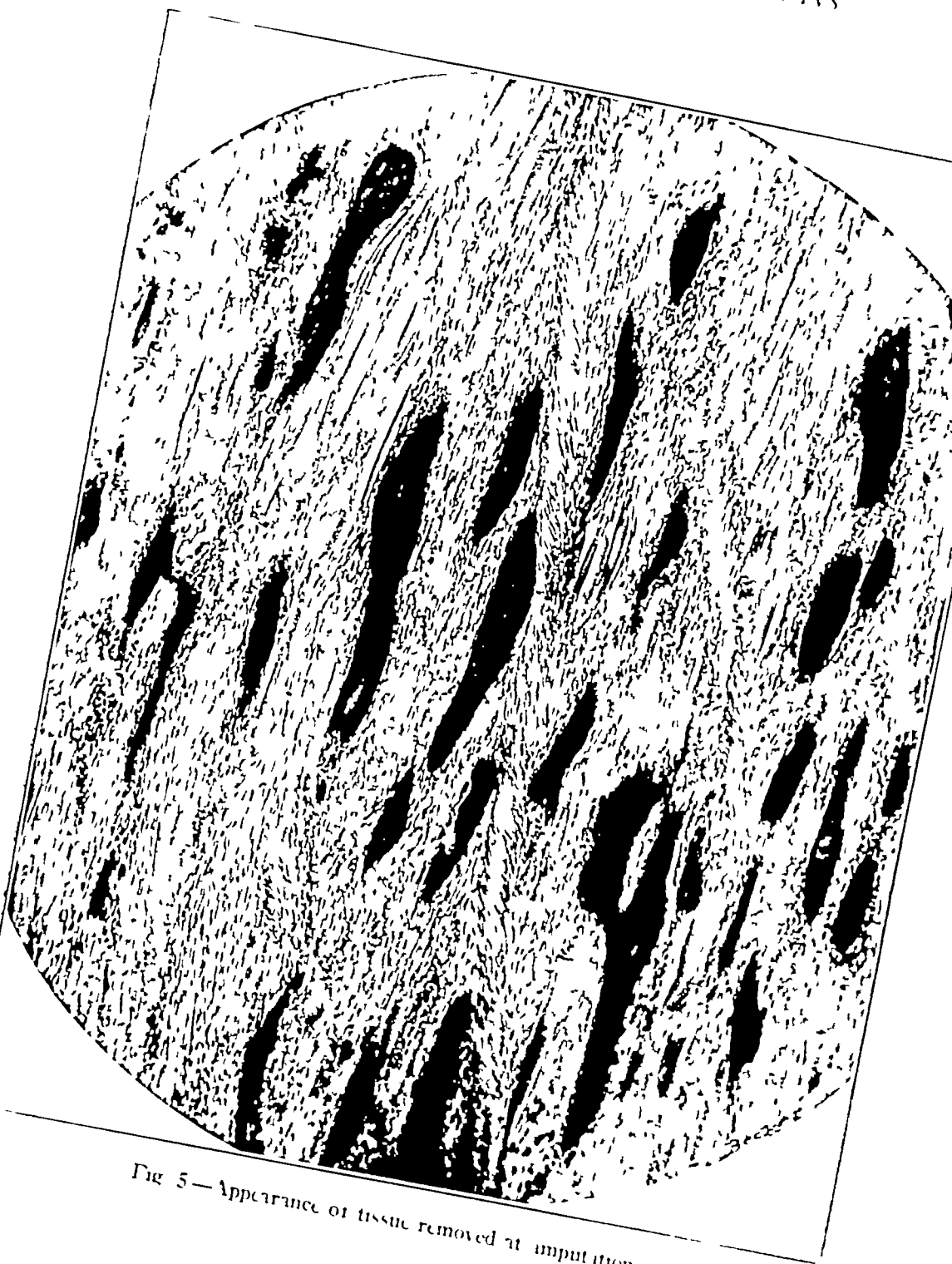


Fig 5—Appearance of tissue removed at amputation

restricted to round cell infiltration, in many cases the formation of giant cells, in some of the appearance of eosinophils, and in all instances the production of granulation tissue and extensive scarring. The liquid and granules are ultimately discharged through fistulas.

The gross manifestations are local or general tumefaction of the affected part and corresponding degrees of deformity. The skin is of normal or darker hue and in cases of long standing mottled with scars. The surfaces of the swellings are studded with nodular or fungating elevations and perforated by irregular pouting openings. From these openings there is discharged spontaneously, or there may be expressed, a peculiar viscid seropurulent fluid with, as the case may be, black, yellow or red grains. A probe introduced into them follows a tortuous course into the depths of the part. Secondary infection alters the appearance correspondingly.

The affected tissues, including bone, slightly resist cutting. The surfaces of sections made by cutting through the tumors are yellow-gray and moistened by the peculiar fluid. The anatomic structures are slightly changed or indistinguishable, depending on the duration of the disease. Muscle and bone, and, less commonly, fascia, tendons and joints are involved to a greater or lesser degree. Any of these tissues may be the site of cellular infiltration, or they may be replaced by gray or yellow oleaginous or myxomatous masses by embedded aggregations of pigmented fungous masses or by abscess cavities. The fistulas usually contain grains, they intercommunicate or extend through tortuous courses to the surfaces of the swellings.

The microscopic features are those of the infectious granulomas, with minor individual variations. The tumors are composed of granulation and fibrous tissue with abscess cavities and fistulas interspersed. At intervals endarteritis, periarteritis and small hemorrhagic areas are commonly found. Compact aggregations of grains are occasionally found in the tissues, but more commonly in the abscess cavities and fistulous tracts. Old fistulas which have discharged their content are filled with round cells, unruptured fistulas contain, besides the grains, fluid in which are suspended polymorphonuclear leukocytes and cellular detritus. The walls of the fistulas and abscesses are composed of central linings of granulation tissue containing young connective tissue fibrils, and older connective tissue peripherally. Centrally there are round cells about the cavities and fistulas, and remotely there are usually epitheloid and giant cells.

A typical microscopic section made by cutting through an abscess cavity or a fistulous tract appears as follows. The grain composed of mycelial elements, pigment and debris is suspended in fluid which fills the cavity of the abscess or fistula. Suspended in the fluid also are polymorphonuclear leukocytes and cellular debris. A zone of tissue

was performed because the shoulder joint became involved and the nerve and blood supply to the extremity were threatened

6 After the first operation the recurrence both clinically and from roentgen-ray study (*D, E, F* in fig 2 and *A B, C D E* in fig 4), more closely resembled sarcoma in its character, the mass was more irregular and was lobulated, which is clearly seen in photographs of dissected specimens (fig 6), the cortex (figs 2, 4 and 6) was irregular and eroded (the result of curetting) I believe that a diagnosis of periosteal sarcoma would undoubtedly have been made at this time had one not had the advantages of the early roentgenograms

be increased or the relative directions of the toes altered, and according to the amount of swelling of the sole they may be elevated from the floor when the foot rests on it. Talipes equinus may be present. In advanced cases the foot may appear as a globose mass of two or three times normal size.

The presence of fistulas through which a peculiar fluid containing grains escapes is characteristic of the mycetomas. The fistulas become manifest on spontaneous ulceration of the skin with resulting rupture of the abscesses. This usually takes place at the apex of a nodule. Fluid containing the grains continues to drain for a few days and then ceases, allowing the mouths of the fistulas to crust over and heal with the formation of scars. The fluid is seropurulent, sanguinolent, often sanious, and contains small grains. By probing, the fistulas are found to originate from deep small abscesses and to pursue tortuous courses to the surface.

Subjective symptoms are few and slight. Pain is rarely present even on manipulation of the affected part, on pressure sufficient to express the grains, or on probing the fistulas. Local tenderness often precedes rupture and drainage of the fistulas, and in some cases sensations of fulness, numbness, heaviness or stiffness are present. The normal sensation in the skin between the lesions is unaltered. In cases with marked swelling or deformity there may be interference with locomotion.

General systemic reactions, including fever, are usually absent. Adenopathy is uncommon. In some advanced cases, there is wasting of the muscles of the leg and rarely cachexia. The systemic reaction when present, is probably the result of secondary infection.

Considering the multiplicity of causative organisms, the clinical types of mycetomas are strikingly few. As Bocarro's analysis revealed in most cases the disease is limited to the extremities and in the greater portion of these to the foot. In his series of 100 cases, the foot was affected in 93 instances, the hand in 3, the leg in 2 and the trunk in 2. The color of the grains is one of the most striking features of any given case and formerly was employed erroneously as the basis for etiologic classification. The species *Actinomyces bovis* is the cause of the disease commonly affecting the facial and cervical regions of man for which the term actinomycosis is usually employed. The species also affects the walls of the thorax and abdomen, the thoracic and abdominal viscera and rarely the brain. In cattle it produces the well known condition of lumpy jaw or wooden tongue. Regardless of the variety of anatomic locations of these diseases the clinical features are rather uniform.

In a typical case of mycetoma the patient may be aware of slight local tenderness at the site of a previous injury for about two weeks before the appearance of swelling. The swelling appears first as a small nodule and gradually extends peripherally as other nodules appear.

characteristically are perforated by sinuses from which seropurulent sometimes sanguineous, fluid containing solid or semisolid granules of varying size, shape and color is liberated intermittently. Pathologically both conditions are granulomas with minor variations and differences in histologic structure, and on microscopic examination the granules from each are seen to contain the hyphae of the causative fungi. There are, however, these comparatively recently recognized distinguishing features—whereas the mycelia of the actinomyces are nonsegmented have poorly defined walls and no chlamydospores, those of the maduromyces are segmented, possess clearly defined walls and usually chlamydospores. Much confusion exists in the recent literature on these diseases, and most of the cases reported were undifferentiated when the reports were made.

#### REPORT OF A CASE

*History*—A negro meat-packer, aged 39 was seen by one of us in the outpatient department of the Minneapolis General Hospital on April 6, 1926. Two days later, he was admitted to the hospital and assigned to the surgical service of the University of Minnesota Medical School. He complained of a swelling of the dorsum of the great toe of the right foot extending to the foot stiffness of the corresponding metatarsophalangeal joint and discharge from the swelling.

The patient considered the swelling as having resulted indirectly from a contusion of the base of the great toe produced by a falling timber in 1914. At the time of the primary injury, he was employed as a laborer during the construction of a cotton-gin shed on a farm near Trenton Tamm County Texas. The injury produced an indentation on the dorsum of the proximal portion of the great toe without causing bleeding or visibly breaking the skin. The part was painful for a time, but after removing the shoe and examining the foot the patient was able to resume work. Primary swelling and soreness continued for a few days and the patient soon might have forgotten the injury except for numbness in the toe which persisted for approximately two years. Recurrence of swelling at the site of the original injury was noted in 1916, soon after the return of normal sensation to the part and approximately ten years before the patient sought admission to the hospital. It consisted of a nodule the size of a "hilt buckshot" which was firm and movable over the underlying structures, but attached to the skin. The size of the swelling slowly increased during the succeeding seven years but within the last three years it had doubled in size. The patient attributed the recent comparatively rapid growth to the increased warmth and moisture of the foot induced by the daily wearing of rubber boots at work about a vat of hot water in the meat packing plant. It is interesting to speculate on the correctness of the patient's deduction.

Stiffness of the metatarsophalangeal joint had been present for two years. It was greatest at the time of the intermittent increases in swelling preceding rupture and drainage of a fistula.

Drainage from the swelling had appeared two years previously and had occurred intermittently. The appearance of drainage was usually preceded for two or three days by tenderness over a small area on the surface of the tumor and followed spontaneous rupture of the skin at the tender point. The patient described the discharge as only streaked with blood and as containing "lumps" which he likened to the "unders" which are discharged through the sinuses

## TREATMENT

The treatment of the mycetomas is surgical. Woolrabe<sup>19</sup> and Audrain<sup>20</sup> have ascribed cures to antiseptics (iodine and mercuriochrome-220 soluble, respectively), but their observations are inadequate. Other antiseptics and germicides and various internal medications, including potassium iodide, copper sulphate, bismuth sodium tartrate, copper citrate<sup>21</sup> and arsphenamine, have been tried without positive beneficial results. Thymol and oil of cinnamon, as applied to other fungous conditions, have been suggested by Gammel. Cauterization has not proved satisfactory.

In early cases, local excision may be sufficient and should be tried, but in advanced cases amputation is the only known curative measure.

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19 Woolrabe, Frederick. Curability of Madura Foot, *J Trop Med & Hyg* **21** 146, 1918.

20 Audrain, L. C. A Case of Mycetoma, *J A M A* **83** 1165 (Oct 11) 1924.

21 Palmer, F. J. A Case of Madura Foot Treated by Chemotherapy. Apparent Cure, *Indian Med Gaz* **61** 74 1926.

stacks of locomotives. By probing with tooth picks the patient often removed the grains from the fistulas; this procedure was not accompanied by pain. Invariably following drainage for a few days, the fistula closed spontaneously in spite of the patient's efforts to promote drainage by the application of poultices. The greatest amount of drainage which had issued from a single fistula was estimated by the patient at a half teaspoonful.

The patient described the grains as black masses varying from the size of a pinhead to that of a pea, round, rough or angular, soft or firm, heavier than water and resembling cinders.

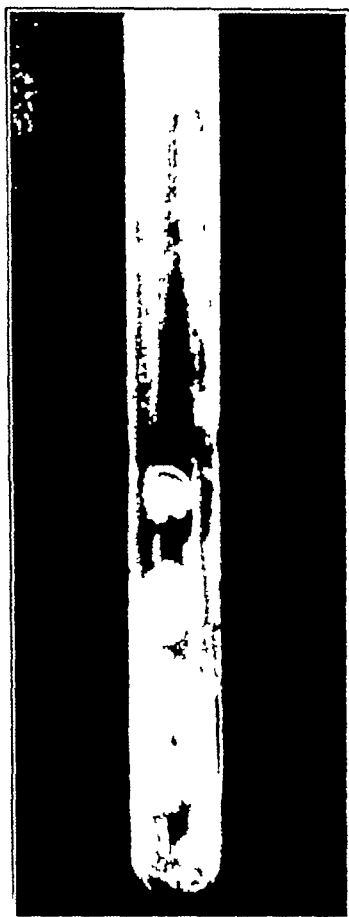


Fig. 3—Colonies of *Madurella alkali* growing on plant agar previously inoculated with washed granules obtained from case of maduromycosis.

The patient was a native of Texas. He had never been outside the United States, but his migrations had included Oklahoma, Missouri, Kansas, and Minnesota. He had been a farm laborer for the nine years previous to his work in the packing plant, which was three years before admission to the hospital. (He had not gone barefoot since early childhood.) Otherwise the history was unimportant.

*Physical Examination*—Results of general examination were negative except for swelling of the foot. The temperature and pulse were normal. The swelling was limited to the dorsum and was situated on the distal medial portion of the right foot and the proximal portion of the great toe (fig. 1). It was approximately the size and shape of half a hen's egg. On the surface of the tumor there were



kidney were more irregular. They usually arose from the lower part of the aorta, at the level of the bifurcation, or from the common iliac of the opposite side.]

Kuksinskaja<sup>4</sup> stated that supernumerary kidneys are the most rare of the renal anomalies. A case is reported in which the supernumerary kidney was also cystic. A survey of the literature revealed twelve similar cases.

The supernumerary kidney is a definite, individual organ, usually found beneath the normally placed kidney. It has its own pelvis, ureter and blood vessels. The ureter may combine with the other ureter and open either into the bladder or into the external genitalia of women or the posterior urethra of men. Usually there are no symptoms to indicate their presence. If infected, the usual clinical symptoms, such as pain, swelling, hematuria or dysuria, are present. The surest method of diagnosis is by cystoscopy and pyelography. Kuksinskaja reported a case of a woman, aged 43, she complained of pain in the right flank radiating into the ileocecal region. Examination and cystoscopy led to the diagnosis of cyst or tumor of a ptotic right kidney. Operation showed a supernumerary cyst of the kidney, the normal right kidney was also found. The cystic kidney, which was 10 by 13 by 5 cm., contained 200 cc of fluid, the cyst was about 9 cm. in diameter on the convex surface of the kidney. Histologically, it was lined with a flat type of epithelium. Proliferative activity was not noted, and a definite cause for the cyst could not be found.

Lazarus<sup>5</sup> reported a case of unilateral fused kidney in which heminephrectomy for calculus pyonephrosis was performed. The diagnosis was made by pyelographic studies. At operation, the renal mass was found to extend from under the arch of the diaphragm to just below the crest of the ilium. When it was freed from its perinephritic coverings, it was seen to be made up of two parts. The upper portion which comprised a little more than two thirds of the entire renal volume, was solid and appeared to be normal renal structure. The lower portion consisted of a fluctuating cystic sac and was densely adherent to the perirenal tissues (perinephritis). It was freed only with the greatest difficulty. There was a well defined line of demarcation evidenced by a superficial groove crossing the mass on its anterior surface, which indicated the site of fusion of the two kidneys. The upper kidney presented a small extrarenal pelvis and a normal appear-

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4 Kuksinskaja, G. F. Cystic einer überzähligen Niere, *Ztschr. f. Urol.* **21** 342, 1927.

5 Lazarus, J. A. Unilateral Fused Kidney, with Report of a Case in Which Heminephrectomy for Calculus Pyonephrosis was Performed. *J. Urol.* **18** 269, 1927.

prominently mentioned by other writers were absent except for a few irregular multinucleated foreign-body giant cells near granules in comparatively dry fields. In the derma, the sweat glands were atrophied corresponding to the amount of connective tissue in the subcutaneous and underlying tissues. Many of the large and medium-sized arteries, as well as the arterioles contained thickened intima. Similar changes were noted in some of the small veins.

The fungus which was isolated in this case was extensively studied by J. A. Gammel of Western Reserve University, who was known to be engaged at that time in the detailed study of a fungus which he had isolated in a similar case. A mycologic report of this fungus has already been published with his review of the American cases of maduromycosis.

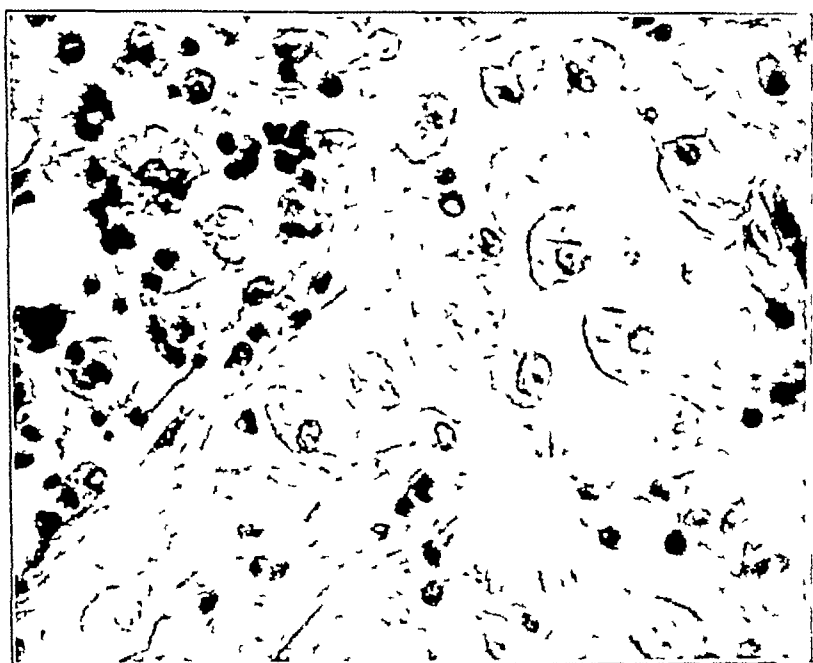


Fig. 8—Foam cells in granulation tissue.

Gammel concluded that this organism is a new species and defined it as follows:

*Madurella ikeda* (Gammel 1926<sup>6</sup>) mycelium gray white later light brown darkening certain sugar mediums. Hyphae hyaline or subhyaline rarely granular varying in diameter from 1.5 to 5 microns. Chlamydospores numerous only in Sabouraud's glucose broth, in all liquid mediums many hyphae break up into chains of lemoniform or round spores. Acuminate light brown colonies on Sabouraud's and Grütz agar. Sclerotia numerous on surface and in depths of Sabouraud's preservative medium (fig. 9), liquefies gelatin ferments rarely, thermophile. Pigment production abundant in glucose, gelatin and maltose moderate in mannite and levulose poor in dextrin poor or absent in milk, beer

6. Gammel J. A. The Etiology of Maduromycosis with a Mycologic Report of Two New Species Observed in the United States. Arch. Dermat. & Syph. **15**: 241 (March) 1927.

a rhabdomyo-adenosarcoma, in the latter adenosarcoma, showing more adenomatous than sarcomatous differentiation. The prognosis in cases of primary renal neoplasms in young children is therefore not entirely hopeless.

[ED. NOTE.—It is well known that the kidney is not an infrequent site for malignant disease during infancy and childhood. The tumor found in most cases is of the mixed embryonic type, although many and varied names have been applied. In many respects these tumors have and still present the problems and diversities of malignant tumors of the testicle. This is not at all surprising when the fact is considered that during the embryologic development of the organism, the genital and urinary tracts originate in close proximity, namely, in the urogenital fold in the anlage of both the mesonephros and the genital gland. These tumors, mixed in constituent tissues, as with testicular tumors, are highly malignant and great destroyers of life. They are a singular and characteristic growth and have presented many problems in pathogenesis.]

The relative occurrence of renal tumor in children is 0.06 per cent (one in 1,600), in adults it is 0.25 per cent (one in 400). The relative frequency of renal tumors among tumors in general in children is 20.4 per cent (one in five), in adults from 0.5 to 2 per cent. Involvement as to the side and sex is about equal, 4 per cent being bilateral. The usual growths are "embryonic mixed tumors," most of them occurring within the first five years of life although they have been found at birth and in later life.

Three hypotheses have been advanced as to pathogenesis. 1. The tumors are due to inclusions of the wolffian body (Birch-Hirschfeld). 2. They are aberrant cells from the myotome, sclerotome and mesenchyme (Wilms). 3. They are descendant from the true embryonic renal tissue or renal blastema and develop by a process of metaplasia (Busse, Muus, Ewing). These "embryonic mixed tumors" may assume large proportions, the average being from 1 to 4 pounds (0.5 to 1.8 Kg.). The pathologic picture presented is an embryonic one dominated by either glandular or cellular tissue, if the former it has been called embryonal adenocarcinoma, if the latter, embryonal adenosarcoma.

The clinical picture is presented usually in the following order: abdominal tumor, presence or absence of pain or hematuria, anemia, general weakness, anorexia and cachexia terminally, and either local or distant metastasis. Tumor nearly always is the initial sign. It is distinguished from neurocytoma, retroperitoneal tumor, enlargement of the spleen, tumor of the liver, hydronephrosis and ovarian lesions. The prognosis is poor, 95 per cent of the patients ultimately dying. The treatment is early diagnosis and radical excision. The use of the roentgen ray has given little encouragement.]

name *Madurella* is proposed for it. As long as the factors which influence permanently the chemical action, biologic behavior and the macroscopic and microscopic aspects of these molds are not known the establishment of new species is justifiable when organisms are found which differ in essential points from known species.

*Subsequent Course*.—On recent examination, Sept. 5, 1927, the patient was found to be in excellent general health. He works at his trade daily. The surgical wound has been healed for fifteen months. At the site of the original swelling

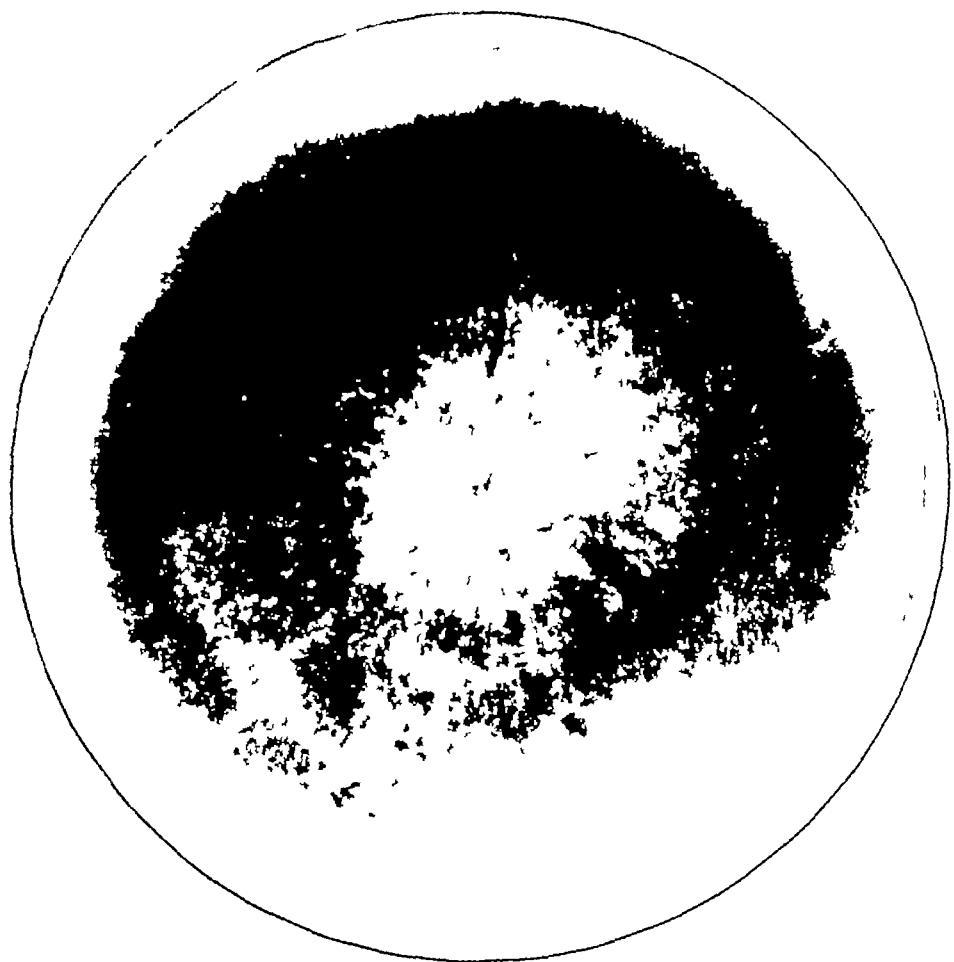


Fig. 10.—Giant colony of *Madurella skedar* (Gammel 1926) on 1 per cent dextrose agar, 2 weeks old. The fungus grows now, one and a half years after isolation, much faster than in the first generations. The dark granules near the center are sclerotic. The agar is deep brown except in the extreme periphery of the plate (natural size).

recurrent nodules and fistulas are present. Granules were recovered from the drainage material. Slight tenderness on the plantar surface of the foot indicates that extension of the inflammatory process in that direction has occurred. The patient does not feel any discomfort while the sinuses are open and the drainage is free. It is probable that amputation ultimately will be required to eradicate the disease process.

signs of mild appendicitis, and a firm lobulated tumor was palpated in the right side of the abdomen. The tumor extended up under the rib and well down within the crest of the ilium. A diagnosis of tumor of the right kidney was made. The usual incision was made and the tumor, which was lobulated, was shelled out, the normal sized kidney which was not connected with the tumor, was pushed up under the ribs.

The tumor, which was extraperitoneal, was removed and apparently consisted of hard lobulated fat. The appendix was removed through the same incision. The tumor was a typical fibrolipoma.

*Tumors of the Renal Pelvis*—Thomson-Walker<sup>9</sup> reported a case of squamous cell carcinoma of the renal pelvis associated with renal calculus. The patient, a man, aged 63, had passed calculi at intervals for twenty-seven years. For two years stabbing lumbar pain had occurred and recently severe attacks of pain about once a fortnight. There had never been hematuria. The right kidney was much enlarged. There was increased frequency of micturition, and the urine contained a heavy deposit of pus and gave a pure culture of *Staphylococcus albus*. The roentgen ray showed a large, heavy, irregularly rounded shadow with a somewhat ill defined edge in the right lumbar area. Right nephrectomy was followed by uninterrupted recovery.

The kidney had the external appearance of a large calculous pyonephrosis. On incision, a quantity of pus and debris escaped from the dilated pelvis. A large, rounded calculus with a rough surface lay in the pelvis in a bed of grayish-white shaggy material resembling asbestos. This material lined the middle third of the pelvis and extended into the slightly dilated calices at this level. It was from 0.3 to 0.6 cm. thick. The surface was shaggy and the upper and lower edges were sharply defined. The renal pelvis and calices above the affected areas were dilated. Microscopic examination of the asbestos-like lining showed leukoplakia which passed into squamous cell carcinoma with cell nests. The infiltration had not penetrated beyond the muscular wall of the pelvis and there was no infiltration of the renal substance. Enlarged lymph nodes were not found at operation.

[ED. NOTE—Squamous cell tumors of the renal pelvis probably result from chronic irritation. Not infrequently, as in this case, there is a history of the presence of renal stone for a long time. These tumors are highly malignant, rapidly involve the renal parenchyma and adjacent tissues, and metastasize readily. Owing to the lack of symptoms suggesting a malignant condition, these tumors are rarely seen when the growth is small or localized to the renal pelvis. In 108 cases of associated renal calculi and malignancy, reviewed by Martin and Mertz, the

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9 Thomson-Walker, John. Squamous Carcinoma of the Renal Pelvis Associated with Renal Calculus. *Proc. Roy. Soc. Med. Sect. Urol.* 20:20, 1927.

## SYNONYMS AND NOMINCLATURE

The conditions referred to in this paper as the mycetomas have been discussed under many names. According to Castellani and Chalmers<sup>6</sup> the natives of India designated them by the vernacular terms "keetenagrah" and 'kirudeo' which appear to have been suggested by the likeness of the tumors and fistulas to the dwellings of worms, and also by the expression 'ghootloo mahdee," probably because of the resemblance of the grains to the eggs of insects. The mycetomas were confused with tuberculosis by some of the early writers, cases were described as 'morbus tuberculosis pedis,' by Godfrey<sup>7</sup> in 1844, and as "Godfrey and Lare's tubercular disease," by later writers. In 1846 Colebrook<sup>8</sup> recorded the name Madura foot as that commonly applied to mycetoma of the foot in and near Madura, a town in the southern part of Deccan India. In 1874, H. Vandyke Carter gave these diseases the scientific name 'mycetoma' (Gr *μύκης* fungus, *ῥμα* tumor). In 1913 Pinoy<sup>9</sup> first used the name mycetoma inclusively for the etiologically distinct conditions, the true mycetomas and the actinomycoses. In 1916 Chalmers and Archibald also used mycetoma inclusively for the subgroups actinomycosis and maduromycosis. The term maduromycosis thus replaced the name 'true mycetoma' of Pinoy. This nomenclature has been adopted by Castellani and Chalmers, Brumpt,<sup>10</sup> Langeron<sup>11</sup> and Gammel.

## DEFINITION OF TERMS NOW IN USE

Previous to the acceptance of Chalmers and Archibald's classification of the mycetomas the term mycetoma had a restricted meaning in that it was the name applied to all the granulomas of fungous origin that occurred in the foot without consideration of the type of causative fungus. With the proposal in the light of added knowledge, of an etiologic classification of this group of similar diseases these investigators returned the term mycetoma as a group name and defined it as follows:

Mycetoma includes all growths and granulations in any of the tissues of man or animals which are caused by fungi belonging to different genera and species, which produce bodies, called grains composed of hyphae and sometimes chlamydospores and which are found either imbedded in the pathological tissues or escaping in the discharge therefrom.

6 Castellani, A., and Chalmers, A. J. *Manual of Tropical Medicine* ed. 3 New York, William Wood & Co. 1919, pp. 2110-2149.

7 Colebrook, cited in footnotes 1 and 3.

8 Pinoy, E. *Actinomycosis et mycetomes* Bull. de l'Inst. Pasteur **11** 929 and 977, 1913.

9 Brumpt, Emile. *Précis de parasitologie*, ed. 3, Paris, Masson, 1922, pp. 965-969.

10 Langeron, Maurice. *Mycetomes in Nouveau traite de médecine* Paris Masson, **4** 445 1925.

ureteral orifice. In cases in which transplantation to the bladder has not occurred, the diagnosis of renal tumor may usually be established from the pyelogram.

Four patients in the series were treated by simple nephrectomy. One of these is living and well three years after operation. One patient died after four years with extensive recurrence in the bladder; two patients died at the end of five and six months, respectively. One patient is living and well seven years after nephrectomy and partial ureterectomy. There were eight cases in which complete nephro-ureterectomy was performed, the ureterectomy from two weeks to as late as twenty-one months after nephrectomy. In four of these, it was necessary to perform simultaneous segmental resection of the bladder for vesical metastasis that had occurred since the nephrectomy. In this series two patients died in the hospital: one from pulmonary embolism on the eleventh day, and the other on the thirteenth day from pelvic peritonitis resulting from a necessary transperitoneal resection of the bladder. One patient of this group was living and free from recurrence at a recent examination five and a half years after operation, another is living four months after operation. Three patients who died from recurrence lived two and a half, three and a half, and seven and a half years, respectively, following late ureterectomy and resection of the bladder for metastasis.

On account of the frequency and involvement of the ureterovesical segment, Hunt believed that segmental resection of the portion of the bladder to include the intramural portion of the ureter and the adjacent area simultaneously with nephro-ureterectomy seems necessary to insure the best prognosis. The results seem to show that the interval between nephrectomy and subsequent ureterectomy is an important factor in the prognosis and is readily obviated by one stage complete operation of nephro-ureterectomy with segmental resection of the bladder.

Hunt stated that if the diagnosis of papillary epithelioma of the renal pelvis has been accurately established by the presence of metastasis to the bladder, it is desirable to proceed with exposure of the lower portion of the ureter and resection of the bladder before the kidney is removed. This facilitates the removal of the entire specimen intact. Through a low median-line incision extending from the pubes to the umbilicus extraperitoneal access to the lower two thirds of the ureter and bladder is readily afforded. The ureter is entirely freed down to the ureterovesical juncture and the base of the bladder is elevated to allow excision of the intramural portion of the ureter and an area of bladder wall around the growth. The resected segment of bladder and the lower portion of the ureter are wrapped in gauze and tucked high in the extraperitoneal space toward the kidney. After the bladder is

writings is correct. Kacmpter is credited by many with being the first to describe them in 1712, using the name perical, but Chalmers and Christopherson have pointed out that this term was applied to any enlargement of the foot including waws and elephantiasis. In 1714 a missionary of Pondichery described a disease of the foot which may have been mycetoma. There is some evidence that Heyne<sup>1</sup> saw a mycetoma in 1806 and Brett's<sup>1</sup> adipose sarcoma described in 1840, likewise may have been a mycetoma. Although the disease probably was known before the close of this period it is difficult to establish the first record of it in the literature.

The Madura foot period between 1846 and 1860 represents the time of definite establishment of mycetoma of the foot as a clinical entity and the period during which some effort was made to establish its identity etiologically. The association in the literature of the disease mycetoma of the foot with the town, Madura, was first made by Gill<sup>1</sup> of the Madura dispensary in 1842, when he called attention to a peculiar disease of the foot. The name Madura foot, however, was first recorded by Colebrook<sup>1</sup> Gill's successor, in 1846 he stated that this was the current name for it in certain parts of India. Between 1845 and 1855 grains were described or illustrated by von Langenbeck<sup>1</sup> from a case of spinal caries, by Lebert<sup>1</sup> from pus from the thoracic wall by Ballingal<sup>1</sup> from a tumor of the jaw, and by Paget and Smith<sup>1</sup> from a swelling of the foot all of which probably were actinomycosis. In 1856, Godfrey<sup>2</sup> at Bellary described a case of what he believed to be tuberculosis of the foot with accidental black deposits and he named it morbus tuberculosis pedis. In 1858, Rustomji<sup>3</sup> recognized varieties of Madura foot represented by black and yellow grains. In 1860 Eyre<sup>1</sup> gave the first complete review of the existing knowledge of Madura foot in which he referred to the presence in the tissues of "tubercles." During this period, mycetoma of the foot became known as Madura foot and by many was thought to be tuberculosis.

The mycetoma period began in 1860 when Carter<sup>1</sup> began his series of publications on Madura foot. Taking note of the various colors of grains, he originated on this basis the first classification of Madura foot. He distinguished black or melanoid, yellow or ochroid and red varieties of the disease. He also recognized the fungous origin of Madura foot but erred in considering the yellow form a degenerative stage of the black, and in maintaining that an organism called *Chinomyphæ carteri* was the cause of the disease. Carter renamed the disease which he had described, and in 1874, published a monograph, 'On mycetoma or the fungus disease of India.' Lewis and Cunningham,<sup>3</sup> in 1875, and Berkeley,<sup>3</sup> in 1876, showed that the chinomyphæ described by Carter was not the cause of mycetoma. In 1886, Carter<sup>2</sup> withdrew his contention regarding the causative organism and likened



other hand, extraperitoneal incision over the abdomen, for example, the pararectal as suggested by Hoffmann for this purpose, should also be applicable

[ED NOTE—Tumors of the renal capsule are not common. As a rule they are not described as such, but are grouped with other retroperitoneal tumors and cysts in the region of the kidney under the head of perirenal tumors. As regards the etiologic and pathologic factors of renal tumors in general, there is great divergence of opinion with regard to the origin of capsular tumors.

Reports of tumors of the renal capsule have rarely appeared in the American literature, the most recent report being by Day<sup>12</sup>. They can usually be classified in three groups: (1) connective tissue tumors of the renal capsule, (2) fatty tumors of the perirenal fat layer and (3) mixed malignant tumors in which occasionally sarcomatous elements predominate. Large fibromas occasionally grow from the capsule or the hilum of the kidney, but they are generally associated with fat, smooth muscle and tissue of the kidney and exhibit myxomatous changes, hence such terms as fibrolipoma, myolipoma, fibromyolipoma, fibroleiomyoma, and myxoma fibromatosum are noted. Lipoma has been found to be most common. Liebermann,<sup>13</sup> analyzing 165 tumors, found the proportion as follows: lipoma, 46 per cent, fibrolipoma, 20 per cent, myolipoma, 10 per cent, fibromyolipoma, 10 per cent, and sarcoma, 14 per cent.

Etiologically, the tumors arise as follows: (1) renal capsule gives rise to the various fibromas and sarcomas in the renal capsule, (2) lipomas in the renal fatty capsule, (3) the embryonic mixed type in the wolffian body and (4) rare hypernephroma in suprarenal rests. It should also be remembered that tumors of the hilum of the kidney that occur only rarely are of a similar nature, especially the lipomatous. Other hypotheses by various observers are of interest. Birch-Hirschfeld<sup>14</sup> has classified the tumors as embryonic adenosarcomas or sarcomatous glandular swelling, believing them to originate from the wolffian body. Haslinger believed that they may be due to pressure on the renal artery or to bleeding in the renal capsule followed by organization. Ewing<sup>15</sup> believed that the growths must owe their origin to some developmental disturbance of the kidney, the nature of which is undetermined.

12 Day, R. V. Perirenal Tumors, *J. A. M. A.* **80**: 840 (March 26) 1923.

13 Liebermann, quoted by Haslinger. Zur Kasuistik der Nierenkapseltumoren, *Ztschr. f. urol. Chir.* **20**: 89, 1926.

14 Birch-Hirschfeld, quoted by Haslinger. Zur Kasuistik der Nierenkapseltumoren, *Ztschr. f. urol. Chir.* **20**: 89, 1926.

15 Ewing, James. *Neoplastic Diseases*. Philadelphia: W. B. Saunders Company, ed. 2, 1922, p. 165.

*myces*, and true mycetoma, caused by true molds. After intensive research and exhaustive review of the literature, Chalmers and Archibald, in 1916, clearly defined the mycetomas and the subgroups and differentiated similar conditions. In a recent report, Gammel listed thirteen species of *Actinomyces* isolated from cases of mycetoma of the foot, and nineteen species of fungi isolated from maduromycoses, including one which he isolated and another which he studied, isolated from the case which Ikeda and I reported.

A number of cases of mycetoma have been observed in the United States. The first case of mycetoma was reported in 1896 by Hyde, Senn and Bishop.<sup>13</sup> In all twenty-two cases have been recorded in the literature. According to Gammel, who made a critical study of the cases, only four are of maduromycosis. The first case of maduromycosis was reported by Wright<sup>14</sup> of Boston in 1898, the second by Boyd and Crutchfield<sup>15</sup> of Galveston in 1921, the third by Gammel, Miskdjian and Thatcher<sup>16</sup> of Cleveland in 1925, and the fourth by me in collaboration with Ikeda<sup>7</sup> in 1927. Boyd and Crutchfield's case was of the white grain type, and the others of the black grain type. The fact that two thirds of the cases observed in the United States have been reported within the last decade from many sections of the country indicates that this group of diseases is beginning to arouse widespread interest.

Although the subject of the mycetomas is still in a confused state, it is obvious that the efforts of Carter, Pinoy, and Chalmers and Archibald have simplified it considerably. Carter recognized the fungous nature of the mycetomas, and the possibility of their being tuberculous in origin was thereby excluded. Pinoy laid the foundation for the work of Chalmers and Archibald whereby the mycologic distinction between the actinomycoses and maduromycoses was set forth clearly. The actual confusion which continues to exist in regard to the etiology of the mycetomas is chiefly botanic and persists largely because the entire subject of mycology is more or less in a confused state. For a clearer understanding of the etiology of this interesting group of diseases further elucidation of the life histories of the causative organisms is necessary.

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13 Hyde, J. N., Senn, Nicholas, and Bishop, D. D. A Contribution to the Study of Mycetoma of the Foot as It Occurs in America, *J. Cutan. Dis.* **14** 1, 1896.

14 Wright, J. H. A Case of Mycetoma (Madura Foot), *J. Exper. Med.* **3** 421, 1898.

15 Boyd, M. F., and Crutchfield, E. D. A Contribution to the Study of Mycetoma in North America, *Am. J. Trop. Med.* **1** 215, 1921.

16 Gammel, J. A., Miskdjian, H., and Thatcher, H. S. Madura Foot (Mycetoma), the Black Grain Variety in a Native American, *Arch. Dermat. & Syph.* **13** 66 (Jan.) 1926.

One of the most striking phenomena in his cases of unilateral tuberculosis is the occurrence of what he terms "unilateral diuresis." This is the discharge from the affected side of urine of low specific gravity, often as low as 1 000 to 1 005, as compared with 1 015 to 1 025 or more, on the sound side. The difference in quantity, specific gravity and the reaction on the two sides is striking, and occurred, in his experience, in over 90 per cent of the cases. On the diseased side there is a free flow of pale urine, faintly acid, neutral or even alkaline in reaction of low specific gravity, containing albumin and pus, while on the sound side there is a sluggish flow of highly acid urine of high specific gravity, often depositing urates on standing. There may be a small amount of albumin on the nontuberculous side, but, failing other evidence of renal inefficiency, he disregarded this in prognosis. If the diseased kidney is removed, the albumin disappears from the sound side, being apparently due to toxins and not to any serious impairment of the remaining organ.

In the rare cases in which cystoscopy and ureteral catheterization are impossible, Fullerton adopts the method of cutting down on the ureter in the iliac region, and catheterizing the ureter through a small slit, which is then closed immediately. This operation is performed by employing the muscle-splitting incision commonly used for removing the appendix. The peritoneum is not opened, but is peeled inward from the lateral wall of the abdomen toward the median line. The ureter remains attached to the peritoneum, and, when recognized, is seized, without being detached, by two special ring forceps by means of which it can be brought up into the wound. A small slit is made and a catheter is introduced. On removal of the catheter, the small aperture is carefully closed by two rows of fine catgut suture. If the ureter is found to be thickened, it is not further disturbed, as it is obviously the ureter of the affected kidney. All that is necessary is to demonstrate the presence and efficiency of a second kidney. Fullerton has performed this operation several times in tuberculous cases.

Fullerton believed that, from a clinical point of view, cure is possible in certain cases without operation. He reported several cases under observation for years in which operation was not performed. Improvement had occurred, although in most cases the symptoms demonstrated that the original lesion was still present. In the cases in which operation has been performed remissions occur, but the general tendency of symptoms is to grow worse.

Fullerton stated that present knowledge justifies the recommendation of nephrectomy for renal tuberculosis with or without secondary involvement of the bladder as being the best and surest method of cure. If done early, before the bladder is involved, the relief is often immediate, and in any case the patient has a better chance of cure and is less

The grains of the mycetomas vary in respect to color, consistency, size and shape. Those of the pale or ochroid variety are white, gray or yellow, those of the melanoid, brown or black. There is also a rare variety in which the grains are red. The grains in some cases are soft and of cheesy consistence, in others firm, hard or brittle. The latter may be softened in caustic potash or eau de Javelle. Ordinarily they are about 1 mm in diameter, but they commonly exist in aggregations which are several millimeters in diameter. Their shapes vary as irregularly spherical, cuboidal, lobate or moruloid, and their surfaces are smooth, faceted or bossy. The yellow grains frequently are said to resemble fish-roe and the black, gunpowder, coffee grounds, pieces of coal or cinders.

Microscopic examination reveals the structure of the grains. The elements contained are mycelia, pigment granules and leukocytes. Often three zones are demonstrable: a central zone, composed of a mycelial reticulum and a varying number of pigment granules, an intermediate zone, irregular, amorphous, and deeply pigmented, and an outer zone refractile, striated and composed of hyphae, usually disposed radially. Leukocytes are present in all zones. The staining qualities of the grains vary.

In teased specimens of soft or softened grains the individual hyphae may be studied, and their characteristics distinguished. The mycelia in the maduromycoses are large segmented filaments, with walls which are well defined, and usually chlamydospores of varying sizes and shapes. The mycelial filaments of the actinomycoses do not have clearly defined walls and are nonsegmented and chlamydospores are absent. The microscopic appearance is the basis for differentiation of the actinomycoses and the maduromycoses.

Growth cultures made from the grains on ordinary mediums and incubated at 37 C., usually appear in a few days in the form of tufts of delicate white filaments. In cultures made from the black grains on dextrose mediums, a rich brown pigment gradually spreads throughout the medium. The nature of the pigment in the grains or in the medium is not known. As pointed out by Gammel, it has been known for some time that each color of grain may be produced by widely different fungi, and it was recently shown that the same species may produce different colors of grains. Therefore the classification of the mycetomas on the basis of the color of the grains is of clinical interest, but of no diagnostic value. Reproduction of the mycetomas in animals has been successful in a few instances.

An excellent recent study of the etiology of the mycetomas in the United States was reported by Gammel. He enumerates thirteen species of the genus *Actinomyces* which have been isolated in cases of actinomycosis, and nineteen species, belonging to two classes and eight genera,

Tuberculosis of the kidneys is more common in children than would appear from the literature, and modern urologic diagnostic procedures such as cystoscopy, ureteral catheterization, tests of renal function and pyelo-ureterography, are frequently indicated in infants and children as well as in adults

Lazarus<sup>20</sup> reported a case of tuberculous horseshoe kidney. At operation the left segment of the kidney was found to be moderately enlarged and close to the lumbar spine. The upper pole was adherent to the under surface of the diaphragm. The ureter was greatly thickened and on section the typical cheesy necrosis characteristic of tuberculosis was noted. An attempt to expose the lower pole of the kidney was futile. The ureter was severed between ligatures and by tracing the lower part of the kidney it was found to take an inward course toward the median line. By carefully pushing the posterior parietal peritoneum mesially, one could distinctly see a thick isthmus of renal tissue crossing over the aorta and vena cava and merging with the kidney on the opposite side.

With the diagnosis of horseshoe kidney established, the pedicle and all the accessory vessels were doubly ligated and divided and the kidney gradually liberated from above downward. By careful digital dissection, the isthmus was separated from the aorta and vena cava and divided between two clamps. The clamps were then removed and a few mattress sutures introduced into the divided end of the isthmus. One tube was introduced into the renal fossa, and the wound was closed in layers.

The specimen, when opened, showed a large tuberculous abscess in the upper pole of the kidney filled with pus and cheesy necrotic material. The cortex over this cavity was much attenuated.

Roschdestwensky<sup>21</sup> (Urologic Clinic of the Tuberculosis Institute of Leningrad) found in the clinical and necropsy examination of 230 cases of tuberculosis of the genito-urinary tract that in all clinically examined cases pulmonary tuberculosis was more or less pronounced, that in the majority of cases the pulmonary process was stationary and well localized, and played only a minor part in the entire picture and that in well defined cases, specific involvement of urinary and genital tracts was comparatively rare. If the urinary and genital tracts were definitely involved, pulmonary tuberculosis showed a favorable course, on the contrary, the genito-urinary tract was more immune against tuberculosis if pulmonary tuberculosis existed.

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20 Lazarus, I. A. Tuberculosis in a Horseshoe Kidney. *J. Urol.* 18:247, 1927.

21 Roschdestwensky, W. J. Ueber den Einfluss der Tuberculose der Harn- und Geschlechtsorgane auf den Verlauf der Lungen-tuberculose. *Beitr. z. Klin. u. Tuberk.* 63:112, 1926.

Thus a total of thirty-two species have been isolated in cases of mycetoma reported from the United States. It is remarkable that a uniform clinical and pathologic picture is produced by so great a variety of fungi.

Gammel pointed out that knowledge of the mycology of most of these organisms is limited and the nomenclature and classification therefore must remain provisional and rather artificial. Fungi parasitic to man are difficult to identify in many cases because they lack the morphologic characters by which the identities of other fungi are determined. These molds are identified, therefore, not only by cultural characteristics but also by pathologic behavior. Many fungi are subject to great variations, and the distinction between new species and permanent variations can be made only after prolonged study. The manner in which some fungous parasites occur in nature is not known. Many of the genera are not well defined and the descriptions of many of the species are incomplete. It is as yet not known in many instances whether differences in color, pigment formation, and the formation of grains are constant features or individual variations resulting from external conditions. Ability of a given species to ferment certain sugars may be either lost or acquired. In respect to the fungi imperfecti, at least, the life histories are imperfectly known, but when in instances they are established they are removed from this class and reclassified with the appropriate groups. For recent classifications of all known species of actinomyces reference may be made to Bergey's<sup>18</sup> manual and to that of Chalmers and Christopherson.<sup>1</sup>

#### PATHOLOGY

Regardless of the existence of this multiplicity of causative organisms, the gross and microscopic pathology of the several varieties of mycetoma is the same except in minor details. The essential pathologic features of these fungous tumors are those which are characteristic of the infectious granulomas, including slowly progressing local necrosis and abscess formation, intermittent discharge through fistulous tracts of peculiar fluid containing characteristic grains, and replacement of the normal structures by granulation and fibrous tissue. In view of the uniformity of pathologic characteristics of the mycetomas, any clinical or pathologic consideration of one or more of them must apply to the entire group.

In man the growth of the fungi is usually sluggish, this permits extensive local reaction. In the tissues immediately surrounding the fungus, liquefactive degeneration takes place, and in this fluid the grains appear to be formed by an aggregation of fungus elements. The tissue reaction throughout the course of the disease remains local and is

<sup>18</sup> Bergey, D. H. Bergey's Manual of Determinative Bacteriology, ed. 2, Baltimore, Williams & Wilkins Company 1925 pp. 345-398.

focus was not found, but was believed to be in the gastro-intestinal tract. The position of the renal abscesses and the pyelographic picture bear out Israël's dictum that chronic actinomycotic abscesses of the kidney originate in the parenchyma as "excretionmycosis."

Bedrna and Pavlica reviewed twelve cases of large actinomycotic abscesses described in the literature as "primary kidney actinomycosis." These abscesses occur in two forms as a tumor with perinephritic symptoms and sterile or cloudy urine and lymphatic involvement and as chronic pyelonephritis with lymphatic involvement and normal or slightly enlarged kidneys, pyelography usually suggests a tumor with this form. The cystoscopic picture may be that of chronic cystitis. The function of the affected kidney is diminished. The prostate is seldom affected.

The treatment consists in nephrectomy. From the reported case it is concluded that the liver must be carefully examined preoperatively. Other treatments mentioned are roentgenotherapy, administration of potassium iodide and copper sulphate and vaccination.

*Renal Stone*—Simon<sup>24</sup> asserted that the formation of stone in the kidney following fracture of the spine and injury to the spinal cord is also accompanied by some type of renal disease. This may be the result either of primary injury to the kidney at the time the spine was fractured, of secondary injury through infection of the urinary tract or of ascending cystopyelitis, the result of injury to the bladder.

The type of stone which forms depends on the secretion of the urine from the injured kidney. There may, therefore, be several types. True urinary stone may form independently of injury to the spine by the deposition of urinary salts, and thereby blood clots or traumatically formed connective tissue in the renal parenchyma give rise to the nucleus, this would cause stones to be formed according to the colloid precipitation theory. The particular type of stone formation (oxalate or urate) depends on the crystalline body content of the urine at any one time. Spinal lesions have little influence on this.

Phosphate stones form secondarily to the decomposition and ammoniacal fermentation of urinary salts. These may be the result of lesions of the spinal cord resulting in paralysis of the bladder, ureter and pelvis, as well as in infection in the urinary tract. Their origination is perhaps favored by lesions of the spinal cord, while in such lesions there is an increased output of calcium phosphate.

Calcium stones form following fracture of the spine and injuries of the spinal cord, because of the absorption of the calcium salts from the fractured surfaces of the vertebrae and from the long bones of the extremities.

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24 Simon, E. Ueber Kalksteinbildungen in der Niere nach Wirbel-Säulenbruch und Rückenmarkslähmung. *Ztschr f Urol* 21: 444 1927.

composed of connective tissue tubules, vascular loops and small round cells constitutes the lining of the cavity or tract. External to this is a more or less distinct intermediate zone of large round and giant cells and a peripheral one of dense connective tissue. In some of the cases reported, eosinophils have been present. The crabs are described elsewhere in this article.

#### Symptoms

The clinical aspect and symptoms, as well as the pathology characteristics of the several mycetomas appear to be identical from the standpoint of present knowledge. Thus from a clinical standpoint, what is said of one, applies to the group.

As the means by which the pathogenic tumor or the mycetomas enter the tissues is not known, statements in regard to the incubation period are merely speculative. Usually it is said to vary greatly or to range from several days or weeks to as long as three months. Such statements are based on the assumption that the tumor can entrance to the tissues through open wounds. A history of previous trauma to the affected part can be secured in probably not more than half the cases, and, when obtainable, antedates the onset of symptoms for a period sufficient to permit healing of the wound. When a history of trauma is obtained it usually is estimated to have occurred from several weeks to as long as several years before the onset of symptoms.

Prodromal symptoms may be absent, or premonitory tumefaction for a period of a few days or weeks; there may be local tenderness or slight redness or discoloration of the skin.

The modes of onset of the diseases are neither uniform nor characteristic. Carter enumerated four modes of first appearance of the mycetomas as: (1) a papule which may be livid or mottled, but which is neither painful nor feverish; (2) a nodule which is deep-seated and fixed; (3) a vesicle surmounting a swollen, hard area; or (4) an abscess which on rupture is found to be a fistula. The most common mode of onset is in the form of a nodule.

In well established cases, swelling is the most prominent symptom. It usually appears first as a small round nodule from 0.5 to 1 cm. in diameter on either the dorsum or the sole of the foot. Subsequently other nodules make their appearance near the first, where the intervening tissue then appears more or less swollen. In advanced cases the entire foot may be touched and its surface studded with nodules or tumorous excrescences.

Variable degrees of deformity result from the swelling. It varies from local tumefaction to general increase in the size of the foot. The concavities of the foot are obliterated first, the bony prominences later. Markedly swollen feet are often said to be club-shaped. The heel and the toes usually remain distinct. The distance between the toes may



attempted lateral suture of the vena cava had to be abandoned as the patient was on the verge of collapse. The vena cava was then doubly ligated both above and below the tear. The superior ligature was just below the anastomosis of the left renal vein. The postoperative course was uneventful, the urine was not suppressed and not until the tenth day was there transient edema of the lower limbs.

Patel believed that the anterior route is desirable for nephrectomy, in this case, it permitted him more readily to carry out the necessary ligation. At this time, a case was discussed by Gayet in which the vena cava was torn during the removal of a large hydronephrotic sac. In this case also the tendency toward collapse made it necessary to abandon attempts to suture the vena cava. Gayet put a clamp on the tear and left it in place after closing the incision, the patient recovered without trouble.

Casper<sup>28</sup> reported two cases in which it was impossible to remove the kidney on account of extensive perirenal adhesions. The first case was that of a woman, aged 23, in whom pyonephrosis developed thirteen years after nephrotomy. The second case was one of infected hydronephrotic sac of long standing. The ureter was ligated and divided in both cases, the upper segment being sutured into the skin. Vesical symptoms cleared readily and there was no further trouble.

*(To be continued)*

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28 Casper, L. (Fehler und Gefahren in der Chirurgie) Schwierige Nephrektomien. *Zentralbl f Chir* 54 79 1927.

The older nodules in succession become soft at their apices, and after a few days spontaneous rupture of the skin takes place with escape of the peculiar fluid containing the characteristic grains. The quantity of the fluid is at first abundant but gradually diminishes after a few days until the fistula crusts over and heals. A small scar marks the site of the fistula. As other nodules undergo the same evolution all stages are usually represented. With gradual extension of the disease, swelling increases and globose deformity of the part ensues. Inconvenience in locomotion results from the size or situation of the tumor or from destruction of the skeletal structures. Cases of twenty-five years' standing have been reported.

#### DIAGNOSIS

The direct diagnosis of mycetoma is simple, provided the possibility of its existence is considered. The swelling, fistulas and grains are often noted by the patient himself, or are easily demonstrable on pressure applied to the part or on probing of a fistula. The fungous nature of the disease is readily apparent on microscopic examination of the grains. Treated specimens for such examination are quickly prepared from the soft grains, the hard may be softened by soaking or boiling in caustic potash, or soda sodium hypobromite, freshly prepared antiformin or eau de Javelle. In such preparations the mycelia are readily seen.

The mycetomas are most likely to be confused in America with tuberculosis, or malignant disease, and in tropical zones also with elephantiasis and yaws. Tuberculosis should be excludable on the absence of fever or by inoculation of a guinea-pig. Sarcoma and other malignant tumors seldom present multiple or transitory ulcers, and biopsy usually may be relied on. In cases of elephantiasis the swelling involves the leg, and there is neither ulceration nor discharge. In yaws there is a general reaction, including fever and a secondary eruption.

The distinction between the actinomycoses and the maduromycoses is made on the appearance of the hyphae. In the maduromycoses, the hyphae are large and segmented, and they possess well defined walls and usually chlamydospores. In the actinomycoses, they are fine and non-segmented, with neither well defined walls nor chlamydospores.

#### PROGNOSIS

The prognosis for cure depends on complete removal of the diseased tissues, as the course is chronic and the mycetomas do not tend to spontaneous cure. After complete removal by excision or amputation, recovery is rapid and there is no tendency toward recurrence in remote regions. The mycetomas are seldom the cause of death except by cachexia or secondary infection.

took the "microscopical examination of the two affected ribs," and communicated his observations to the *Dublin Quarterly Journal of Medical Science*

The three reports of Dalrymple, Bence-Jones and McIntyre, in the hands of subsequent investigators, were accorded a widely variant degree of attention. Had this been otherwise, perhaps the name of Dalrymple instead of Rustizky (writing twenty-seven years later in 1873) might have been credited with the histologic definition of this disease, and McIntyre instead of Kahler (whose work appeared thirty-nine years later in 1889) cited as the first author to describe multiple myeloma in connection with the excretion of Bence-Jones bodies. Between 1848 and 1873, only three probable cases were added to the literature. These reports were made by Herman Weber in 1867, by Crudeli in 1871, and by Adams and Dowse in 1872. After Kuhne, in 1882, and Stokvis, in 1883, the work of Kahler, in 1889, was responsible for calling attention to this disease.

In Italy, the works of Bozzolo in 1897 and 1898 awakened a series of contributions (over 40 case reports) paralleling the stimulus lent to German clinicians by Kahler's article (followed by some 135 case reports). Although English works must be granted the priority in this field, their contributions have not been so numerous as the German.

Perhaps the best reviews on the subject are to be found in Martini's article from Italy in the *Policlinico* and Wallgren's article from Sweden in the *Upsala*. Rosenbloom, in America, has published a good bibliography of the literature through 1916.

Rather than include a review of the general literature on the subject we have appended, in chronological order, all the case reports which we have been able to compile from a study of the extensive contributions published on this subject. This bibliography gives an historical representation of the progress in this subject and affords to those especially interested an opportunity to check the observations reported here.

#### ETIOLOGY

Multiple myeloma is essentially a disease of later life, approximately 80 per cent of all cases occurring between the ages of 40 and 70, with the peak of incidence at 55. In this respect, it closely follows other malignant diseases, coinciding almost exactly with the age incidence of a series of 100 cases of metastatic carcinomatous skeletal tumors studied in the surgical pathological laboratory of Johns Hopkins Hospital.

Young adults are not spared, although we have been able to find only five cases occurring in adults under 35. Two of these cases in patients aged 33 and 32 years were not proved microscopically (Anders and Boston). Williams, Evans and Glenn reported one case in a patient

# A REVIEW OF UROLOGIC SURGERY

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## KIDNEY

*Anomalies*—Surraco<sup>1</sup> reported a case of crossed ectopic kidney. The right kidney was normal and in good position. The left kidney, which is the one usually displaced, was crossed and partially fused with the lower pole of the right. Both kidneys had lost their normal shape; the pelves were on the anterior surface and the ureteropelvic junctures were lateral to the kidneys. The ureter to the left kidney crossed the median line at the level of the second sacral vertebra, this is important embryologically as it suggests the area in which the ureteral bud found its first obstacle in its ascending progression.

[Ed. Note.—Ectopic kidneys of this type do not usually cause symptoms, but at times, owing to their bulk and situation, there is considerable pain. Caulk<sup>2</sup> reported a case in which suspension and fixation of the kidney to the lumbar fascia partly relieved pelvic pain and a constant desire to urinate.

Stewart and Lodge<sup>3</sup> reviewed twenty-eight cases of unilateral fused kidney. They found that the displaced organ generally lies below the normally situated one, its upper pole fused with the lower pole of the latter. The ureter from the upper kidney generally enters the same side of the bladder. Usually three or four arteries pass to the fused organ, of which two supply the upper and two the lower half. One or both vessels to the upper part of the kidney arise directly from the aorta, in or below the normal position. The vessels for the lower part of the

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1 Surraco, L. A. Considerations sur le rein ectopique croise, *J. d'urolog. med. et chir.* **23** 411, 1927.

2 Caulk, J. R. Surgery of the Ectopic Kidney, *Ann. Surg.* **78** 65, 1923.

3 Stewart, M. J., and Lodge, S. D. Unilateral Fused Kidney and Allied Renal Malformations, *Brit. J. Surg.* **11** 27, 1923.

Many unsatisfactory attempts have been made to estimate the incidence of myeloma. Symmers and Vance found 3 cases among 4,000 autopsies at the Bellevue Hospital, and in 9,000 autopsies at the Johns Hopkins Hospital there were 4 cases.

We have found myeloma in about 0.03 per cent of all types of malignancy. This incidence is based on life insurance tables in which sarcoma in general is seventh in frequency in the list of malignancy, or 3.5 per cent, with sarcoma of the bone one third of this, or about 1 per cent. Among 400 cases of sarcoma of the bone in the surgical path-

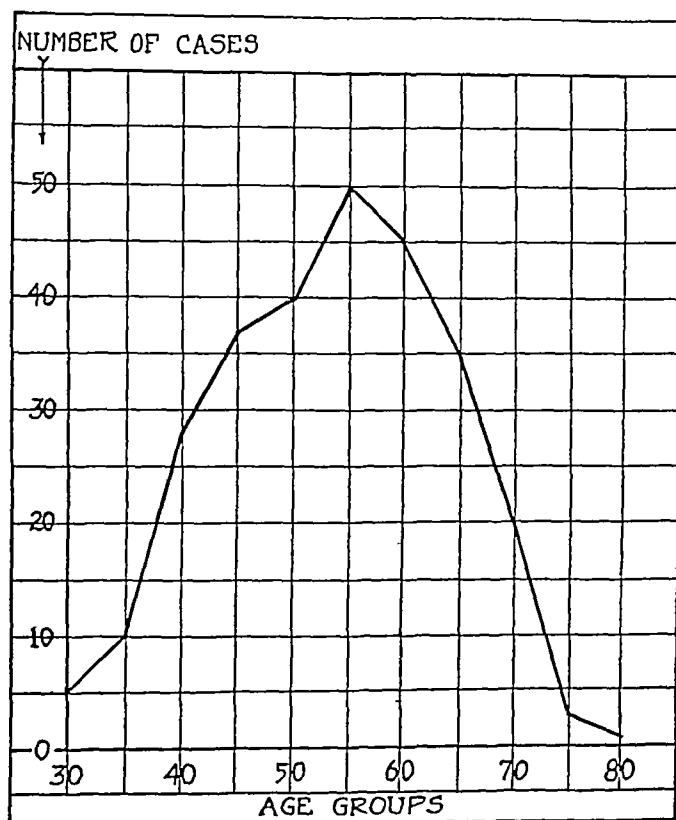


Fig 2—Age incidence in cases of multiple myeloma

ological laboratory at the Johns Hopkins Hospital, 3 per cent were multiple myeloma.

There is little that can be said definitely concerning the actual causative agents of multiple myeloma. Meagerness in the majority of the case reports precludes reliable conclusions drawn from the previous history of these patients.

In isolated cases, some fact in the family history is stressed. The statement by Dornvick that a brother of the patient with myeloma, whose case was reported by Stokvis and Kuhne, died of the same disease, is open to question. Kalischer and Hoffman attributed etiologic significance to a family history of pernicious anemia in their case. In one

ing ureter which passed over the anterior surface of the mass. The pelvis belonging to the ectopic portion was greatly dilated and wrapped up in a mass of inflammatory fat. Its ureter was of normal size and was seen lying on the anterior surface of the kidney and proceeding downward and to the left. The pelvis was dissected free of adhesions with great difficulty and its blood supply inspected. There were two sets of large vessels entering the fused kidney. The upper set arising from the aorta and vena cava crossed the upper border of the dilated pelvis of the ectopic kidney and entered the hilum of the right kidney. The lower set arose from the right common iliac and coursed along the lower border of the dilated pelvis to enter the kidney in its lateral surface. These vessels were clamped, cut, doubly ligated and divided. The ectopic kidney was freed with great difficulty and delivered and during this procedure several aberrant vessels were encountered. These were ligated and divided and the ectopic kidney resected through the groove indicating the line of fusion. The divided end of the upper kidney was closed with three mattress sutures of plain catgut. The kidney was then decapsulated and through a small nephrotomy wound a tube was introduced into the renal pelvis. The kidney was finally replaced in its bed and carefully surrounded with perirenal fat. The patient left the hospital with the wound practically healed.

**Tumors**—Wollstein<sup>6</sup> reported a series of eighteen renal tumors in children, their ages varying from 3 ½ months to 6 years, seven were in the first year, two were more than 3 years of age and nine were between 1 and 2. Ten were girls and eight were boys. Ten of the tumors were in the right kidney and eight were in the left. All tumors were unilateral, retroperitoneal and within the renal capsule.

Wollstein noted that these tumors may be in any portion of the kidney. Microscopically all were embryonic, one was an unmyxoid spindle cell sarcoma, thirteen were adenosarcomas, three were leiomyo-adenosarcomas, and one was a rhabdomyo-adenosarcoma. Embryonal renal neoplasms occurring in young children are a heterogeneous group, being closely related but not identical histologically or histogenetically. The fully developed renal tissue does not have any part in the formation of tumor. The author adds that the more solid tumors are more easily removed because they remain within their capsules. Four children who survived operation ten months or more had this type of tumor. Metastasis into the lungs and liver may develop into the firm type of growth as well as the softer ones, but metastasis appears less frequently and less early in the former type. One patient survived to adult life and one is well six years after operation. The growth in the former was

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<sup>6</sup> Wollstein, Martha. Renal Neoplasms in Young Children. Arch. Path. 3:1 (Jan.) 1927.

diseases, although prone to involve the bone and the joints, are not of great clinical rarity and do not warrant particular emphasis

From time to time, theories regarding the infectious nature of myeloma have been propounded and the occasional febrile course of the disease stressed. More plausibly, the elevations in temperature can be ascribed to intercurrent infections. All in all, the etiologic obscurity that is attached to malignancy seems to extend in no less degree to multiple myeloma.

#### CLINICAL CHARACTERISTICS PAIN

Pain is the outstanding symptom at the onset of myeloma which causes the patient to consult a physician. Although, when its course is viewed in its entirety, the pain is seen to be typical in many of its features, the initial phases are particularly vague and indefinite.

Most frequently the pain at the onset of the condition is characterized as rheumatic. It is wandering and intermittent, but is generally confined to the back. In 70 per cent of the cases the pain is found in the lumbar or sacral regions, in 20 per cent, in the chest over the ribs or sternum, in 5 per cent, in the legs, arms or shoulders, and in 5 per cent, in other parts of the body.

Often the pains are described as neuritic. Girdle sensations, or radiation of pain down the legs is of common occurrence. One of the chief features of the pain is the aggravation of it by motion or pressure. Although subject to remissions, it is capable of acute exacerbations.

It is generally just such sharp accentuations of pain, brought on by sudden movement or muscular exertion, that first calls the patient's attention to the severity of his illness. Most frequently such an unexpected climax of pain is brought about by the strain of lifting a heavy load (Meyerding, cases 10 and 6, Wallgren, Copeland and Geschickter, case 1) or by some inexplicable fall (Devic and Beriel, Cathcart, Bruce Lund and Whitcomb, and Anders and Boston). These attacks are usually exceedingly severe and leave the patient in a state of prostration and collapse. In case 1 in this paper, the patient was chopping wood, when an overzealous effort precipitated a stroke of pain which felled him to the ground, where he lay motionless for many minutes in a state of utmost pain and anxiety. In a case cited by Kahn, the sudden halting of a train in which the patient was seated, was sufficient to bring on the attack. McIntyre related the incident of vaulting out of an underground cavern, and a consequent prostrating siege of pain. One of Wallgren's patients was overtaken by a seizure when he was going down some steps, he tumbled headlong down the remainder of the flight and sustained a fracture of the radius.

The result of such an attack is to leave the patient for the next few hours or days with bone-breaking pains in the lumbar and sacral regions.

Nicholson<sup>7</sup> noted that renal or abdominal symptoms accompanied by fever, are not necessarily indicative of new growth. There is much evidence, however, to show that fever is associated with uncomplicated neoplasms, although not as frequently as with inflammatory disease.

In a review of the literature it was found that Briggs noted fever in 38 per cent of cases of new growth and in 45 per cent of cases in which ulceration had occurred. renal malignancy, however, was not mentioned. Israël, in 146 cases of tumor of the kidney and suprarenal glands noted fever in 8 per cent of the uncomplicated cases. Israël felt that the cause of the fever must be looked for either in the rapid growth of the tumor cells or in the destruction of normal tissue. Necrobiosis, which occurs in all malignant tumors, should not always be considered the cause of the fever since fever is not always present even when this occurs. Voelcker stated that fever is not infrequently present with hypernephroma. There were cases extending over a period of a week with temperatures as high as 102 F. Cases were noted in which the temperature was the initial sign of the disease. In speculating as to the cause, Voelcker refers to the absorption of albumin bodies produced by the process of involution, also mentioning as a possibility that inflammation of the renal pelvis plays a part, because this structure is often invaded by plugs of necrotic new growth. Berg believed that the great size and rapid growth of hypernephroma were factors in the cause of the increased temperature. Castano, in a series of seven cases, found that chills had occurred in two and irregular fever in one. In each case fever subsided following nephrectomy.

Nicholson observed a case that of a woman, aged 38, who had had fever almost continuously, intermittent abdominal pain and general weakness. A correct diagnosis had not been made in spite of careful observation over a period of eleven months. Roentgen-ray examination then showed widening of the hilum of the lung. Seven months later, eighteen months after the onset of the illness, annular opaque areas appeared in the lung and a diagnosis of tumor, probably Hodgkin's disease, was made. Fever had been present almost continuously for twenty months. Necropsy showed carcinoma of the lower pole of the right kidney with metastasis to the left suprarenal gland, spleen, liver and lungs.

Cullen<sup>8</sup> reported a case of fibrolipoma simulating tumor of the right kidney. The patient was a small girl having signs of digestive disturbance and pain in the right lower quadrant. There were definite

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7 Nicholson, Daniel. Fever with Renal Carcinoma. *Arch. Path.* 3: 393 (March) 1927.

8 Cullen, T. S. A Fibrolipoma Closely Simulating in Form and Location a Tumor of the Right Kidney. Subacute Appendicitis. *Surg. Gynec. Obst.* 45: 152, 1927.



of an acute onset. In over 75 per cent of the cases, however, the course of the disease, while averaging in duration between one and two years, is insidious in its onset.

#### TUMOR

Not infrequently, tumor formation is the initial symptom that calls attention to the disease.

The distribution of the tumors in cases of multiple myeloma is perhaps the most outstanding diagnostic feature of the disease. The multi-

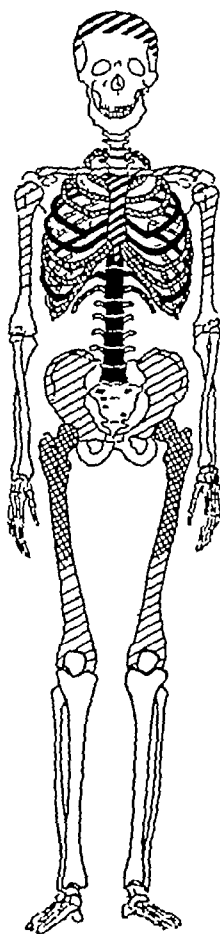


Fig. 5—Incidence of skeletal involvement according to location. The solid black area indicates the most frequent site, the heavy diagonal lines, the common sites, the checked areas, the fairly common sites, the light diagonal lines, the occasional sites, and the white areas, rare sites.

plicity of the tumors is a cardinal point. In only five cases (Wallgren [case 13], Ewald, Schmorl, Morax, and Geschickter and Copeland) has the disease been found with a single focus, and in all of these cases autopsy was not performed, nor thorough roentgen-ray studies made. There is multiple involvement of the ribs, sternum or clavicles and spine in 90 per cent of all cases. In nine of ten patients with myeloma there is tumor involvement of the ribs, sternum and spine, of the ribs, clavicle

symptoms suggestive of stone averaged nineteen years in duration the symptoms suggestive of malignancy usually had been present about five months. Most stones found in cases of carcinoma of the renal pelvis are rough and irregular, they are usually of the staghorn, earthy phosphate type, and may be extremely large. Kaufmann reported a case in which the stone weighed 93 Gm. A similar case was noted by Oraison in which the patient had had attacks of renal colic for twenty-eight years, the stone weighed 107 Gm. Wells and Kundrat also reported cases of squamous cell tumors associated with large branching stones. Stones occurred in six of eleven cases in which the condition was considered by Wells as definite squamous cell carcinoma. The operative mortality is high, and the majority of patients who survive die shortly after the operation for local recurrence or metastatic growth.

Five cases of squamous cell tumor of the renal pelvis were seen at the Mayo Clinic between 1907 and 1922. Renal stone was associated in four of the cases. The stones in three kidneys were extremely large and of the staghorn type. One patient died eight days after operation, three others died during the first four months. The fifth patient is alive and without symptoms of recurrence six months after operation.]

Hunt<sup>10</sup> stated that twenty-three of 318 malignant tumors of the kidney removed at the Mayo Clinic were primary in the renal pelvis. Eight of these were highly malignant sessile epitheliomas, the remainder were relatively benign papillary epitheliomas. All of the first group of patients (seen since 1910) have died. The results in the latter group have been better, six patients are living and well, three less than a year later, and three for seven, five and three years, respectively. Of the nine who died, one lived seven and a half years, one lived four and a half years, one three and a half years, one two and a half years and five less than one year after operation. Sessile epithelioma progresses and extends by invasion into perirenal tissues and renal veins, and metastasizes remotely, while the papillary type progresses by extension along the mucous membrane of the calices, ureter and bladder.

Hematuria is the most constant symptom of papillary tumor. It occurred in all of the cases in this series. The presence of a palpable enlarged kidney is usually dependent on the presence of hydronephrosis. A large renal tumor was palpable in five of the cases, and in each instance was due to hydronephrosis. The presence of a papillary tumor of the bladder at or near the ureteral orifice, as seen on cystoscopic examination, should immediately give the clue to the diagnosis. Such a tumor was present in but four cases on primary cystoscopic examination; in a fifth case a small amount of papillary tissue projected from the

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<sup>10</sup> Hunt, V. C. Papillary Epithelioma of the Renal Pelvis. *J. Urol.* 18: 225, 1927.

Boggs and Guthrie, Bomhard, Madsen, Blatherwick, and Wallgren) If the larger tumors are in the sternum, clavicle, ribs or skull, their true nature is probably discovered earlier than when the larger masses are confined to the spine, where they are obscured by mere stiffness or beginning kyphos

The tumors have been variously described as elastic, yielding, pliable or malleable. Often a parchment-like crepitation may be elicited over



Fig 7 (case 3) —Gross specimen of humerus showing central location of tumor

the thin bony shell of the tumor, and where the tumor mass itself is not made out, the bones give the sensation of yielding and fragility. Occasionally, true pulsation may be observed as in the case of Rustizky, or semifluctuation may be made out as observed by Cathcart and Bruce.

Although painless tumors have been described, it is usual, especially in the later stages, for the tumor sites to be extremely painful. The mere touch of the hand, the pressure of a stethoscope or the movement of the bed clothing may be unbearable. The approach of the physician to the bedside is often sufficient to make the sufferer cringe with fear of impending torture.

reconstructed and the anterior incision is closed the patient is turned on the side, and through the posterolateral incision which gives access to the upper third of the ureter the kidney, ureter and bladder are removed intact

*Tumors of Renal Capsule*—Johansson<sup>11</sup> reported two cases of tumor of the renal capsule one a fibroleiomyoma in a man aged 57 the other a fibrolipoma in a woman, aged 47

Pararenal tumors are relatively rare About one half of all retroperitoneal lipomas originate from the tissues around the kidney and only a small proportion of these start in the renal capsule These tumors often reaching considerable size, may grow in either a lateral or a medial direction, in the latter case extending widely into the mesentery, where there is least resistance They may have little, if any, attachment to the kidney or else grow around it, encroaching on all sides

In the absence of contraindications and if technically practicable, the treatment in such cases should be operative, if operation is not performed, one must reckon either with sarcomatous degeneration or else with sequences from the mere size of the tumor which alone may demand its removal There are thus a number of cases described in which extirpation had been impossible because of technical reasons and in which the patients died later on account of mechanical disturbances created by the tumor, such as compression of the lungs intestines or ureters, or from cachexia At postmortem examination one may also find that such a tumor was the cause of death

The prognosis, however, even if the radical operation is performed is far from favorable The primary mortality is already high, often owing to technical difficulties with risk of hemorrhage and injuries to intestines In a series of cases reviewed by Wahlendorf death occurred in about 30 per cent either as a direct result of operation or from some cause closely related to it To this may be added the fairly great risk of sarcomatous degeneration The operative cases have not been under observation sufficiently long to determine how great this risk may be

Histologically, benign tumors also recur fairly frequently and in a number renewal of operative procedures has been indicated In certain cases this is probably explained by the fact that tumors have grown diffusely at an early stage and thereby prevented radical removal

These tumors are generally of considerable size at the time of operation and extraperitoneal exposure by a lumbar incision would therefore meet with fairly great difficulties In Johansson's cases the tumors were exposed successfully by the transperitoneal route On the

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<sup>11</sup> Johansson Sven Two Cases of Tumor of the Renal Capsule *Acta chir Scandinav* 61 197 1926

Less commonly, when the skull is involved, there may be interference with mastication. In a case of Anders and Boston the teeth fell out. In Schmorl's case, the skull is reported to have increased 3 cm in diameter during the course of the illness—a rare occurrence in cases of myeloma and more typical of Paget's disease.

#### FRACTURE

The bone destructive nature of the tumors in myeloma is very exemplified by the frequency of pathologic fracture in this disease.

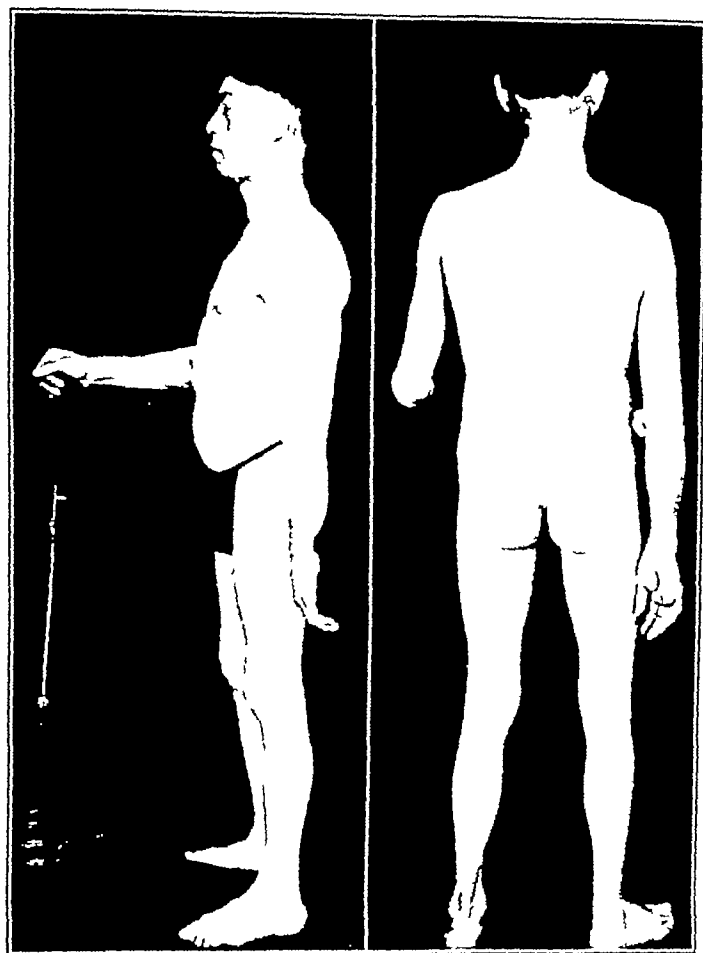


Fig 8 (case 1) —The stance of a patient with myeloma, showing the protruding abdomen, the approximation of the ribs to the pelvis, the obliteration of the lumbar curve, and the wide base assumed on standing.

Although often escaping clinical recognition, in no other tumor of the bone does fracture occur in so large a proportion of cases.

In his study of pathologic fracture made in the surgical pathological laboratory of the Johns Hopkins Hospital and reported in Scudder's work on fractures, Dr Bloodgood found an incidence of 38 per cent in cysts of the bone, 25 per cent in multiple myeloma and 21 per cent in metastatic tumors, these three classes of tumors having the highest incidence of fracture.

In connection with the wolffian body it is of interest that these tumors occur much more frequently in women. Hinman, Gibson and Kutzmann<sup>16</sup> have discussed the role of the wolffian body as an etiologic factor and found that more evidence is gradually being collected to support the view that a great variety of cystic and solid neoplasms of the retroperitoneal space in relation to the suprarenal kidney, broad ligament, spermatic cord, epididymis and possibly the testis have their origin in remnants of the wolffian body. In the complex development of the urogenital tract abundant opportunity for misdevelopment undoubtedly exists while the numerous fetal remnants left over in the process of development afford an attractive explanation. The anaphora cysts have been noted much oftener in female than has been explained as being due to the relatively greater amount of the remnant of the wolffian body in the female as compared to the male. The latter utilizes most of the primitive primary excretory apparatus in the formation of the vas deferens and epididymis whereas in the female the major part of the wolffian body remains atrophied.

Clinically these tumors produce few, if any, symptoms. Except for the sarcomas, they grow slowly, tending to encompass the kidney without invasion of the renal capsule. As a result urinary symptoms are rare. These tumors will continue to grow and fill the lumbar and renal space with pressure encroachment on the adjacent organs, hence such symptoms as dyspnea, edema and constipation occur. The renal mass has been known to increase so as to weigh from 30 to 60 pounds (14 to 27 Kg.). Gastro-intestinal symptoms, especially nausea and vomiting, are usually the most prominent. Barring the absence of urinary disturbances, the physical signs are similar to those of renal tumors. The tumors occur with greatest frequency in adults between the third and fifth decades.

Preoperative diagnosis is rarely made, due to the number of other confusing conditions. The treatment is complete radical excision. This is not always technically possible because of the danger of injury to the adjacent vital organs as well as the possibility of extensive infiltration. For this reason the operative mortality is high (50 per cent). There is a decided tendency to recurrence of the benign as well as the malignant tumors, thus the ultimate prognosis is bad.]

*Renal Tuberculosis*—Fullerton<sup>17</sup> reviewed his series of 150 cases of tuberculosis of the kidney and bladder. He believed that primary tuberculosis of the bladder rarely exists and that the sequence of events in many cases is infection of the kidney, followed by secondary involvement of the prostate vesicula and epididymis.

16 Hinman, Frank, Gibson, J. E., and Kutzmann, A. A. Cysts of the Wolffian Body, *Ann Surg* 79: 762, 1924.

17 Fullerton, Andrew. Tuberculosis of the Bladder and Kidney. *Irish J. M. Sc.*, 1927, no. 13, pp. 5-14.

encountered in the same bone, the occurrence of several fractures in various different bones is exceptional. Not infrequently, however, in cases of multiple myeloma, fractures occur in the same patient in several ribs, clavicle and sternum. Sometimes both lower and upper extremities as well as the thoracic cage are involved (Morse, Hansen, Wells, Symeys and Vance, Osgood, Belden, Gaube, Martini, Meyerding, Jellinek, Cathcart, Bruce, Lund and Whitcomb, and in our cases 2 and 9).



Fig 10 (case 3) —Pathologic fracture through the neck of the left humerus. Note the rarified condition of the clavicle and the mottling of the ribs.

Both united and ununited fractures are met with in myeloma. Union of fractures, which is generally slow, has been described by Ellinger, Jellinek, Cathcart and Bruce, Scarlani, P. Weber, Ledingham, and Dialti. In Moore's case, rapid union of the clavicle occurred. In one of Meyerding's cases, in which both femora were fractured, the left united while the right failed to do so.

Spontaneous dislocation of the sternoclavicular joint has rarely been described (Martini, Howard and Crile). Gradual dissolution of a rib may occur so that the mere pressure of the stethoscope is sufficient to

susceptible to the crippling effects of scar tissue in the bladder, his immunity from recurrence of the growth elsewhere is also greater.

Ide<sup>18</sup> stated that renal tuberculosis, which usually remains unilateral for a long time, should be treated by nephrectomy. Edema and hypertension are positive signs of bilaterality and exclude surgical intervention.

Medlar stated that renal tuberculosis may heal spontaneously in the first stages, and that it is usually present in fatal cases of pulmonary tuberculosis. In twenty-two of thirty cases of fatal pulmonary infection, tuberculosis bacilli were found in the kidney, usually in the cortex. The kidney follows the same laws of tuberculation as the lungs, which in the majority of cases do not undergo curetion.

Stevens<sup>19</sup> reported a case of renal tuberculosis in which the inoculation tests on guinea-pigs were positive with urine taken from both the right and the left kidney. Following right nephrectomy, repeated inoculation tests with urine from the remaining organ were negative, and when last seen, one and a half years later, the patient was apparently in good health.

Apparently normal kidneys may sometimes permit the growth of tuberculosis to pass. Hobbs reported that they were found in the urine of more than 8 per cent of 422 patients suffering from pulmonary tuberculosis, but without any other symptoms referable to the urinary tract. The kidney may be definitely involved without causing symptoms. In 143 cases of advanced pulmonary tuberculosis, involvement of the kidneys could be detected microscopically in 55 per cent; in only a few were symptoms of renal tuberculosis present during life. In 3766 other cases of pulmonary tuberculosis reported by various observers, renal involvement was noted microscopically at necropsy in 588, or in a little more than 15.5 per cent. Wildbolz, stressing the value of functional renal tests, stated that in more than 500 nephrectomies he had not been misled in a single instance by the use of indigo carmine or cystoscopy as functional tests, and that the questions whether or not renal tuberculosis is present and, if so, whether unilateral or bilateral, are to be answered with certainty only by means of functional tests of the kidneys. He does not consider a small amount of pus and a few bacilli of tuberculosis pathognomonic of renal tuberculosis unless there is a decrease in function.

Stevens concluded that repeated examination of the urine by means of smears and inoculation of guinea-pigs are sometimes necessary in order to discover the bacilli of tuberculosis. Roentgenograms are positive in a much larger number of cases than is generally appreciated, and they should be more frequently employed in the diagnosis of renal tuberculosis.

18 Ide. *Tuberculose renale*, Rev. med. de Louvain 1927, no. 3, pp. 47-49.

19 Stevens, W. F. *Diagnosis of Renal Tuberculosis*. I. A. M. A. 88:71 (Jan. 8) 1927.



by the tumor of the vertebral column. This together with other forms of neural disturbances is found in about 40 per cent of the cases.

The paraplegia that develops is due to compression of the spinal cord by vertebral tumors most frequently located in the lower dorsal or the lumbar region. The onset is usually insidious, marked at first by weakness of the legs with a tendency to stumbling. There is dwindling sexual appetite, hesitancy in starting the flow of urine and diminished epicritic sensation over the lower extremities. In the next stage, there is exaggeration of the reflexes with development of a positive Babinski sign and ankle or patellar clonus.

In the final stage, there is a flaccid paraplegia with incontinence and the development of decubitus ulcers. The involvement will rarely be unilateral (Meyerding, case 6). In an unusual case reported by the same author (case 9), paraplegia came on after a fall and then gradually disappeared. In a case studied by Bertoye, there was a paralysis that recurred after temporary cessation. These rarer forms of receding neurologic involvement parallel the occasional regressive changes seen in the tumors of the bone in cases of myeloma and are related to vascular changes in the spinal tumor.

In a smaller percentage of the cases, the diverse involvement of the skeleton gives rise to neurologic symptoms in other regions. In cases reported by Bloodgood, Anders and Boston and Hammers, diplopia developed. In Meyerding's third case, anisocoria and failing vision accompanied a tumor of the skull. In a case of Herz, paralysis of a hand was present. In Senator's case, glossoplegia with partial laryngeal and pharyngeal paralysis developed, and Stokvis found difficult deglutition in his patient. There was decided alteration of the voice in a case studied by Anders and Boston.

Wallgren and also Venturi reported cases with tumors in the skull giving rise to thromboses in the intracranial sinuses. In Venturi's case, there was thrombosis of the central artery of the retina with complete blindness. Diminution of vision was present in Askanazy's case.

Not rarely tumor masses of the ribs give rise to intercostal neuralgia and paravertebral tumors to radiculitis with severe lightning-like root pains. Such involvements are sometimes complicated by herpes zoster (Conti, Anders and Boston, Bomhard, Wallgren, and our case 1).

Senator and others, lacking definite anatomic proof that direct impingement by tumor is responsible for many of the lesions of the nerves already described, ascribe to them a toxic origin. Evidence of tumor, however, is almost always found in the region of the neurologic symptoms, which would not necessarily be so were a circulating toxin the agent responsible for these disturbances. Ginsburg,<sup>2</sup> in describing

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<sup>2</sup> Ginsburg: Hodgkins Disease With Predominant Localization in Nervous System. *Arch. Int. Med.* 39:571 (April) 1927.

The North British found evidence of tuberculosis in other parts of the body either healed or active in 244 of 349 cases of renal tuberculosis. He believes that it is questionable whether renal tuberculosis ever occurs unless there is tuberculosis in some other tissue. Coincident tuberculosis, particularly if healed or dormant, does not necessarily render the prognosis less favorable after nephrectomy, in fact it may be regarded as evidence of the patient's good resistance. Pulmonary tuberculosis is one of the most common co-infections occurring with renal tuberculosis. Renal tuberculosis is also a common complication of active pulmonary tuberculosis, it occurred in a coincident infection in less than 5 per cent of each sex in the Mayo Clinic. Evidence of healed tuberculosis, however, present in 14 per cent of all patients affected with renal tuberculosis.

Further, in two or two cases (1) treated 126 patients who had tubercle of the suprarenal glands by either nephrectomy or autophrectomy. In 55 per cent the symptoms had existed for more than a year before operation was done. In 70 per cent the tumor was imperceptible, in 74 per cent it did not vary in size, in 10.3 per cent given in the last 28 per cent in size. In 20 per cent the cysts were not palpable and in three cases malnutrition. In 54 per cent of the cases the blood was normal, in 9 per cent the urea was elevated. Adrenoma and pheochromocytoma were continually present. The preoperative diagnosis made the differential diagnosis simple. In thirteen cases there were not found in and urine which is no characteristic of tubercle. Many cases of mixed tuberculosis had been common through the colonial India, the disease following nephrectomy. One patient did not wish to be operated on and became well following autophrectomy. In all other cases in which operation was not performed the process continued to a fatal termination.

*Actinomyces*. Bodini and Pacher<sup>1</sup> reported actinomycosis in a man, aged 38, examination had revealed pain in the left hip and a palpable tumor in the left side of the abdomen. There was diminished function of the left kidney and albuminuria. Roentgenograms and the nebrite course indicated a tumor. Although spasticity of the iliopsoas muscle indicated infection. Objective or subjective symptoms of disease of the liver were not present. The kidney was removed, and a large active actinomycotic abscess was found. There were also many abscesses in the fatty capsule and the iliopsoas muscle. The patient died the third day after operation with signs of hepatic insufficiency. At necropsy two large abscesses were found in the liver. The primary

22 Runberg B. Tuberkulose der Hirnorgane. Finska Lakarsällsk. Handl. Helsingfors, 1926, abstr. *Ztschr. f. Urol.* **21** 380, 1927.

23 Bedrna, J. und Pavlica, F. Aktinomykose der Niere Čisopis lékařů českých 1926 no. 35-36 abstr. Ztschr. f. Urol. **21** 396 1927

in other cases, the paraplegia was the underlying condition with urinary retention and an ascending infection giving rise to cystitis, pyelitis and renal abscess. In our seventh case, the urinary infection followed paraplegia and could be ascribed to the use of a retention catheter.

Metastases (Froenkel, Morse, and our case) have more rarely been demonstrated in the kidney.

Great interest is attached to the association of nephritis and Bence-Jones bodies in cases of multiple myeloma. This occurs frequently and we found both in ninety-two cases, as shown in figure 11.

Decostello, by injection of Bence-Jones bodies into dogs, concluded that a previous nephritis was necessary to their excretion. Stokvis, on

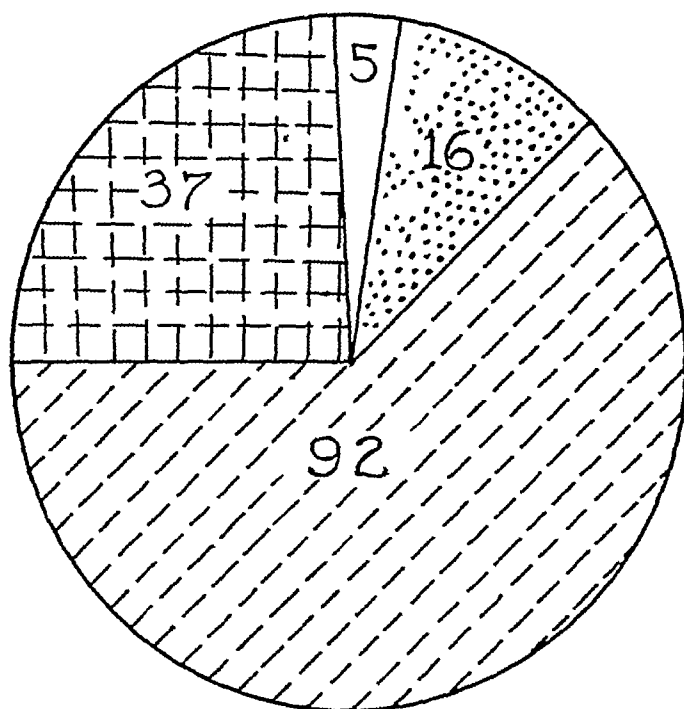


Fig. 11.—Nephritis and Bence-Jones bodies in 150 cases of myeloma. The white area (3.3 per cent) indicates an absence of nephritis and Bence-Jones bodies, the dotted area (10.7 per cent), Bence-Jones bodies only, the crossed area (24.6 per cent), nephritis only and the area of broken lines (61.4 per cent) nephritis and Bence-Jones bodies.

the other hand, claimed to have induced nephritis in these animals by similar injections of Bence-Jones bodies. Longcope's work on the effects of foreign protein on the kidney in man would seem to support the contention of Stokvis, that nephritis might thus be brought about.

No single theory for the origin of nephritis has a monopoly on the evidence at hand. While in some cases Bence-Jones bodies are reported in the urine without the ordinary albuminuria expected with foreign protein shock to the kidney, still it is possible that by repeated damage to the kidney a dysfunction is brought about.

*Renal Circulation*—Johansson<sup>25</sup> reported a case in which the gradual obliteration of the vessels of the hilum caused the formation of capsular collaterals. The case was one of chronic pyelonephritis with calculus. Nephrectomy was performed, and when the kidney was detached from inside the capsule it was found to lie free in the operator's hand without a trace of bleeding. The kidney was lying inside its own capsule as a kind of sequestrum even though its excretory function had been maintained. Pulsation was not felt in the vessels of the hilum. The pedicle was tied and the fibrotic capsule removed. The arteries of the hilum showed marked endarteritis with thickened intima poor in cells but without obliteration. The veins were wide, one or two smaller branches were filled with recent thrombi. The arterial branches near the cortical limit showed increasing endarteritis, in most places almost obliterated and in some places completely obliterated.

Endarteritis was not marked in the capsular arteries, which were numerous and relatively large. Transitional branches of these vessels were observed to pass across toward the parenchyma of the kidney and in several places were traced for a distance of 2 mm into the cortex.

The partial obliteration of the vessels of the hilum caused hyaline degeneration of many glomeruli. The capsular vessels, which did not show any obliterative or endarteritic changes, had developed in great numbers not only in the capsule itself but in the superficial layers of the cortex with communicating branches of arteries and veins passing across.

Meyer and Singer<sup>26</sup> considered spontaneous perirenal hematoma as a definite entity usually necessitating immediate surgical intervention. This condition causes severe pain, signs of internal hemorrhage, formation of an enlarging tumor in the loin and at times hematuria and signs of peritoneal irritation.

The authors are disposed to regard perirenal hematoma as they do intestinal obstruction. The diagnosis of mechanical obstruction of the bowel being established, the indication for operation is usually clear. Preoperative knowledge of the etiology, although highly desirable, is not essential in the decision as to the form of management, whether medical or surgical, and when the presence of a perirenal hematoma is established, whether or not the cause is known the case ordinarily becomes surgical.

*Nephrectomy*—Patel<sup>27</sup> reported a case in which the vena cava was torn during the removal of a large tuberculous right kidney. An

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25 Johansson Sven. Question of Collateral Circulation in the Renal Capsule. *Acta chir. Scandinav.* 61:181, 1926.

26 Meyer K. A. and Singer H. A. Spontaneous Perirenal Haematoma and Aneurism of the Renal Artery, *Surg. Gynec. Obst.* 45:300, 1927.

27 Patel. Ligature de la veine cave au cours d'une nephrectomie. *Presse med.* 35:633, 1927.

## GASTRO-INTESTINAL SYMPTOMS

In a disease running a fatal course, many terminal complications are to be expected, and certain of the gastro-intestinal symptoms of patients with myeloma are apparently on this basis. The diarrhea often met with and the colicky pains described (Meyerding, Wallgren, Wright, Austin, Bozzolo, Bertoye) are associated with the conditions found at autopsy in most instances of enterocolitis, which, as MacCallum has pointed out, is often a terminal complication in patients with nephritis.

The fatal hematemesis in Bertoye's case, the melena in Wallgren's case 11, and the epistaxis not infrequently observed (Anders and Boston, Bertoye, Kriebich, Hoffmann, Bradshaw and Warrington, and in some of our own cases) likewise may be regarded as terminal manifestations associated with a lowered platelet count in marked anemia (as pointed out by Naegeli).

There is an occasional case of outspoken peptic ulcer (Vance, P. Weber, Wallgren), however, which is more difficult to explain. Gastric analyses have been done in only rare instances (Wallgren, McConnel, and our own cases). These determinations, with few exceptions, show an absence of free hydrochloric acid. To complicate the picture one step further, metastases or extensions of the tumor to the stomach and duodenum have been reported in cases of Renzi, Martelli and Morse. Ulcer formation has not been correlated with tumor formation in these rare instances.

The most frequent gastro-intestinal symptoms are nausea, vomiting and colicky pains. In some cases, there is vomiting without nausea. In cases reported by Meyerding, Wallgren and Jacobson, and in our own series, these gastric disturbances have been associated with compression of the spinal cord, and were perhaps analogous in some way to the gastric crises found in *tabes dorsalis* (as suggested by Martini).

The various types of gastro-intestinal symptoms already mentioned represent about 20 per cent of the cases.

## METASTASES

It was long thought that multiple myeloma never involved the internal organs by metastases, and that if metastasis occurred, it was merely as a spreading from one bone to another of a tumor growth primary in a single focus or an original group of foci. Direct extension to surrounding parts was conceded, but when tumor growths were found in the liver and spleen, Lubarsch sought to explain them as separate nodules in hemopoietic tissue, arising independently rather than by metastases.

Actual metastasis to internal organs however is not at all rare when a careful review of cases has been made. The spleen has been reported as the site for metastases in cases by Arnold Aschoff, Madsen,

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## MULTIPLE MYELOMA\*

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BALTIMORE

To the future understanding of malignancy, present day medicine has made its major contributions in the form of analyses of these conditions into clinical entities, and there has been much of therapeutic advantage in the earlier diagnoses thus made possible. In regard to multiple tumors of the bone, much remains to be accomplished in this direction by a compilation of a more complete series of cases thoroughly studied both clinically and pathologically.

In the present article multiple myeloma has been selected for discussion from among the multiple tumors of the bone. To the group of thirteen cases (comprising our own series) has been added an analysis of all available cases reported in the literature since 1848—in all, a series of 425 cases. Our work is based largely on the material placed at our disposal by Dr Joseph C Bloodgood, in the surgical pathological laboratory at the Johns Hopkins Hospital.

### HISTORICAL

Dr William McIntyre, in reporting the first case of multiple myeloma adequately described in the literature, relates the following:

Mr M—a highly respectable tradesman, aged 45, placed himself under my care on the 30th of October, 1845. On taking charge of the case, I had the advantage of meeting Dr Watson, whom the patient had consulted at the beginning of the preceding summer.

On the 15th (Nov. 1845) Dr Bence Jones, who had been for some time engaged in examining the composition of the patient's urine, met us in consultation. At his suggestion alum was added to the tonics in use with the view of checking the exhausting excretion of animal matter. (The animal matter referred to is now known as Bence-Jones bodies.)

The foregoing citation brings together the names of McIntyre, Watson and Bence-Jones, who were jointly responsible for the study of this case. In his report McIntyre also refers to Dalrymple<sup>1</sup> who under-

\* From the Surgical Pathological Laboratory, Johns Hopkins Hospital.  
1 Dalrymple. Dublin Quart. J. M. Sc. June, 1846.

evidence for this statement failed to disclose its source. In the present study, excretion of these bodies was reported in 65 per cent of all cases.

On the other hand, a search for an albuminoid substance in the urine of patients with diseases other than myeloma, although infrequently carried out, has shown this substance to be present in a widely variant group of bone and bone marrow diseases. In 107 cases of diseases other than multiple myeloma in which we could find (either in the literature or in the surgical pathological laboratory of the Johns Hopkins Hospital) a record of a determination, Bence-Jones bodies were found in twenty-six cases. Most of these tests, of course, were made on patients suspected of having myeloma, and the results throw some light on the value of the test in differential diagnosis.

TABLE 1—*Bence-Jones Bodies Found in the Urine of Cases Other Than Multiple Myeloma*

A BONE DISEASES			No of Cases
Disease	Reference		
Metastatic tumors of the bones	Orrum, Bradshaw, Boston, Boggs and Guthrie, the authors		9
Multiple sarcoma of the bones	Seegelman, Gilmore		2
Senile osteomalacia	Rascke		1
Polyfibrocystic disease	Groves		1
Comminuted fracture	Campbell with Horsfall		1
Caries of the spine	Willgren (cited)		1
Tumor of the jaw	Fitz		1
Total			16
B BLOOD DISEASES			
Lymphatic leukemia	Herz, Frohman, DiCastello	Askmarzy	4
Myelogenous leukemia	Simon, Moore, Authors		3
Chloroma	Weinberger		1
Polycythemia	Pribram		1
Experimental aplastic anemia (in a dog)	Zulzer		1
Total			10
Total, all cases			26

Table 1 has been compiled from the literature and from cases in the surgical pathological laboratory of the Johns Hopkins hospital.

Despite the fact that twelve different conditions are enumerated in the foregoing table, the striking feature that all of these diseases involve either the bone or bone marrow is well emphasized. In the case of Fitz, so often cited as an example of Bence-Jones bodies in myxedema, actual perusal of the reference showed the patient to have a tumor of the jaw with sequestra in addition to the hypothyroid symptoms. The case of Coriat in which these albuminoid bodies were found only in the pleural fluid has been referred to by some as milary tuberculosis, by others as multiple sarcomas. Coriat, in reporting the case, did not describe symptoms of either, contenting himself with remarks concerning the rare and obscure nature of the patient's condition. The evidence would, therefore, seem to indicate that the excretion of Bence-Jones

aged 30, Moore reported one in a patient, aged 27, and Habersfeld and Lordy, one in a patient, aged 22, all three cases being microscopically verified

Some uncertainty is attached to the occurrence of multiple myeloma in children. Cases reported by Roman (1912) and by Elizalde and Llambias (1913) are not considered myeloma by Wallgren. A case reported by Gilmore (1925) and submitted to the Codman Registry (serial 260) was diagnosed myeloma by Woods and Smith, with Bloodgood, Wolbach and Mallory dissenting. The two cases reported by Berkheiser (1925) resemble the xanthoma variant of the giant cell tumor in one instance, and Ewing's endothelial myeloma in the other. The ages of the children in the various cases reported vary from 2 to 12½ years

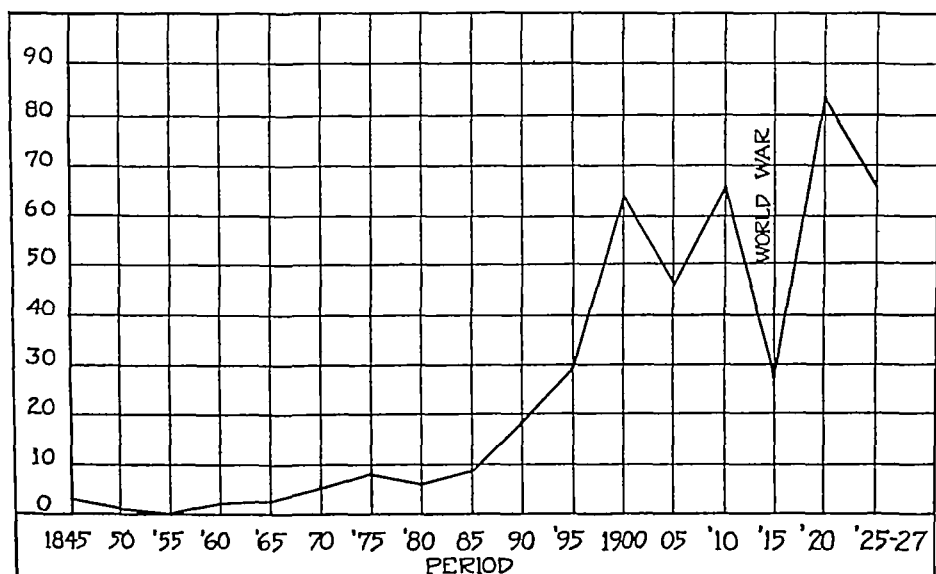


Fig 1—Distribution of 425 reports of cases of myeloma by five year periods from 1845 through 1927

In regard to sex, the occurrence of myeloma in males, roughly estimated, is twice as frequent as in females. Anders and Boston, reviewing thirty-three cases of myeloma, found 80 per cent in males, Wallgren found 68 per cent of males in ninety-eight cases, and in our series of cases, 70 per cent occurred in males.

The occurrence of myeloma appears to be widespread. Reports are numerous from England, America, Germany and Italy. Cases have been described in all parts of Europe—Scandinavia, Russia, Holland, France and Switzerland—in Canada, in Australia and in South America. McCallum and Hamburger have described the disease in a negress, and Jacobson has found it in a Chinaman. The disease apparently does not favor any particular social strata of society nor does any special climate or region appear to be immune.



occasionally been found. There is the usual anisocytosis and poikilocytosis found in a marked anemia.

The white blood cell count and its differential count present certain peculiarities. In 100 white blood cell counts 70 per cent of the cases are within normal limits, 23 per cent show leukocytosis and 7 per cent a leukopenia. The majority of the cases in which there is a leukocytosis range in counts from 11,000 to 15,000. In this respect there is no peculiarity, for we would expect to find leukocytosis in patients who so generally suffer from secondary infections.

The unusual features occur in the differential count. In about sixty cases with complete differential count, myelocytes ranging between 1 and 10 per cent were found in fifteen cases and eosinophils ranging

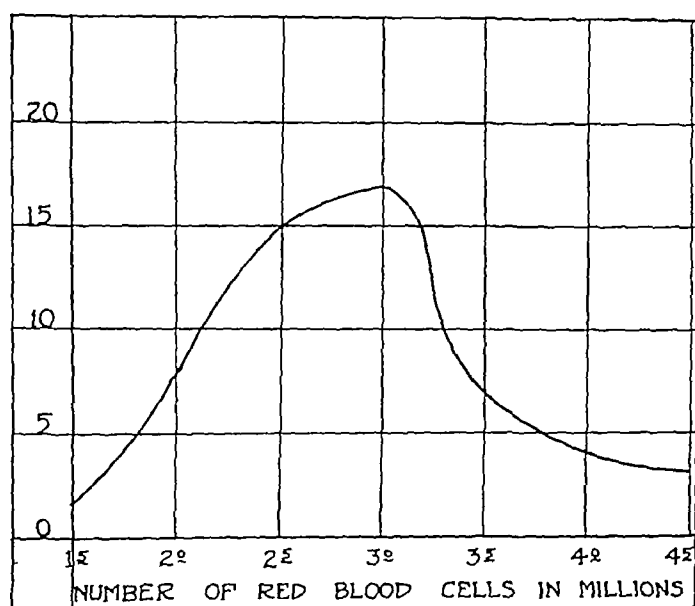


Fig. 14.—Red blood cell counts in 70 cases of myeloma. The left hand column shows the number of cases.

from 3 to 5 per cent in five cases. Vaughn,<sup>4</sup> has reported myelocytes as a common occurrence in cases of advanced carcinoma, an interesting point in this connection. Abnormal mononuclears or Turk's irritation phenomena were found (the authors, Wallgren, Weinberg, Schwartz and others). In general, there is a tendency for the mononuclear elements to increase, a relative lymphocytosis not rarely being present. In some cases, the tumor cells have been reported circulating in the blood (Beck and McCleary, Ruzinsky and Reichenstein, Aschoff, Weinberg and Schwarz, Stumm, Wallgren and Aschoff). The exact identity of such cells, however, has not been established. An occasional case of malignancy with tumor cells in the circulation has been reported for other

4 Vaughn. Operable Cancer, J. A. M. A. 69 1952 (Dec 8) 1917

of Meyerding's cases, the aunt of the patient had a bone disease with a pathologic fracture of the leg

With respect to trauma, so much stressed in tumors of the bone, there is more plentiful, if not more convincing, evidence at hand. Although trauma as a factor in the disease was probably not sought for in a considerable portion of the cases, we found it in the history of 20 per cent. When recorded in some cases, it precedes the disease by an interval sufficiently long to render its significance questionable (Hopkins and Savory, Marchand, Funkenstein, Hansen, and our own cases 1 and 10 with intervals of from nine to thirty years). More frequently, the justifiable conclusion is that the trauma was superimposed on a pre-

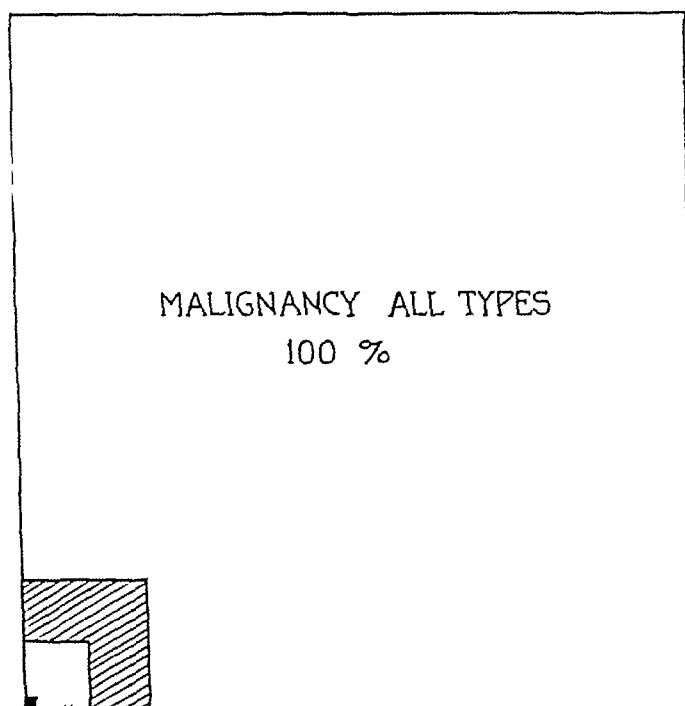


Fig 3—Incidence of multiple myeloma. The white area indicates all types of malignancy, 100 per cent, the area with diagonal lines, all sarcomas, 35 per cent, the dotted area, bone sarcoma, 1 per cent, the solid black area, multiple myeloma, 0.03 per cent.

existing diseased state, since it is of such slight nature that in healthy persons symptoms could hardly have been produced (Wood and Locke, Belden, Osgood, Meyerding, Wallgren and others).

Infection has been cited by some as a suspected causal agent. In patients with myeloma the combined incidence of influenza, malaria and typhoid is approximately that of trauma. When one considers the frequency of these infections among all classes of patients, however little remains to be said in regard to their special significance for this disease. Tuberculosis, syphilis, osteomyelitis and infectious arthritis are found associated with myeloma and sometimes coexistent with it. These

diseases (Schleip in gastric carcinoma with vertebral metastases Marcus Quennell in sarcoma) In view of the fact that myeloma cells can be found in the vessels pervading the tumor areas, such occurrences are not remarkable

As a group, these cases present rather remarkable conditions in their blood picture The high hemoglobin in 38 per cent of the cases is contrary to the ordinary secondary anemia of malignancy, nor is there the aplastic type of anemia bespeaking widespread bone marrow disease, which one might expect The normoblasts and megaloblasts typifying regeneration, and the eosinophils are also contrary to what one would expect The absence of leukemia is not suggestive of a tumor of hemopoietic tissue

The condition is complex In some cases, there is a tendency for a displacement of hemopoietic tissue by tumor elements with consequent anemia simulating the primary type On the other hand, in the more chronic cases, a course resembling malignancy may give rise to an anemia of the secondary type Either of these two conditions may gain the ascendancy, and this gives the blood picture of multiple myeloma a variable character

#### ROENTGEN-RAY OBSERVATIONS

When complete roentgen-ray studies are made of the patient with myeloma much is generally to be found that is typical of the disease and helpful in making a diagnosis

The changes taking place are characteristically distributed in the trunk, in the sternum, in the ribs and in the spine The skull is not rarely involved, and when the long pipe bones are affected, there is a tendency for the tumors to be located about the pelvic or shoulder girdles, not infrequently affecting the pelvis The lesions are characteristically multiple and, in general, confined to the location of the red marrow, and thus in the roentgenogram may be termed typically central

The tumors themselves are bone destructive and frequently show up in the pictures as rounded, punched-out areas varying from the size of a pea to that of an orange Sometimes they are more diffuse, giving a rarefied osteoporitic appearance to the roentgenogram, or, when multiple areas have become confluent, resembling mottling

In the thoracic cage, the ribs are most frequently diffusely mottled, but at the site of the ossified costochondral junctions, there is a tendency for the tumor nodules to stand out more distinctly as areas of bone absorption Not infrequently, tumors about the size of an almond are to be seen lying on the ribs, rather than appearing centrally At autopsy they can be found projecting inwardly as subpleural nodules

Pathologic fractures occur most frequently from the fifth down to the twelfth rib The break is generally not a clean one, but a default through a widened and rarefied area of rib easily overlooked In some

or over the lower ribs. From this stage of relatively intense pain the affliction usually passes over into a period of intermittency, an asymptomatic period which may last as long as several months or even a year. This period in which the malady is apparently arrested is fairly characteristic of multiple myeloma, and it is during this interval of pseudocure that many of the patients have been discharged from the clinics, to fall into the hands of chiropractors and charlatans when the later stages of the disease become manifest.

During the final stages of the disease the pain reaches a climax in which it is at a maximum severity. It is here that portrayals of suffering of the most agonizing sort are to be found in the literature, and it is in this stage that complicating root pains, paresthesia and neuralgia appear.

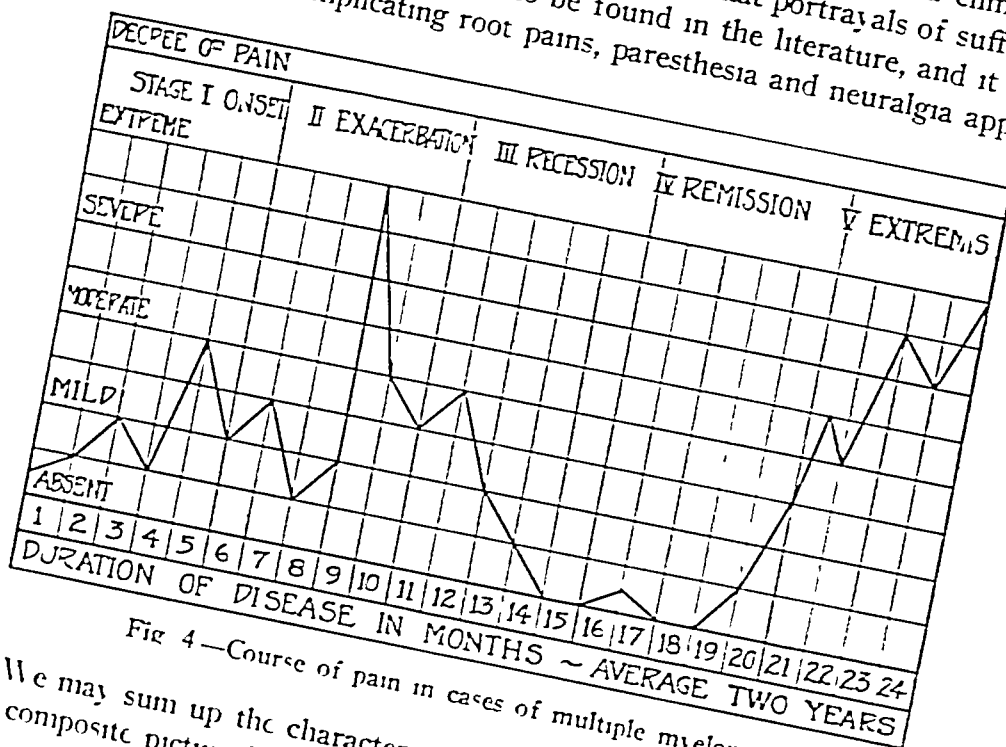


Fig. 4—Course of pain in cases of multiple myeloma

We may sum up the characteristic course of the pains in a more or less composite picture by the following outline:

- Stage 1 Intermittent insidious wandering pains rheumatic or neuralgic, radiating or girdle in character worse on motion or pressure.
- Stage 2 A dramatic incident of aggravation with increase of intensity of pain marked by collapse, prostration and bone-breaking pains.
- Stage 3 Subsiding intermittent pains.
- Stage 4 Relative freedom from pain with symptomatic relief.
- Stage 5 Recurrent progressively intense pain proceeding to death—complicated by neurologic manifestations.

In almost every case studied the course of pain described here had been manifest in one or more of these stages. Occasionally the terminal stage only will come under observation and this will give the appearance

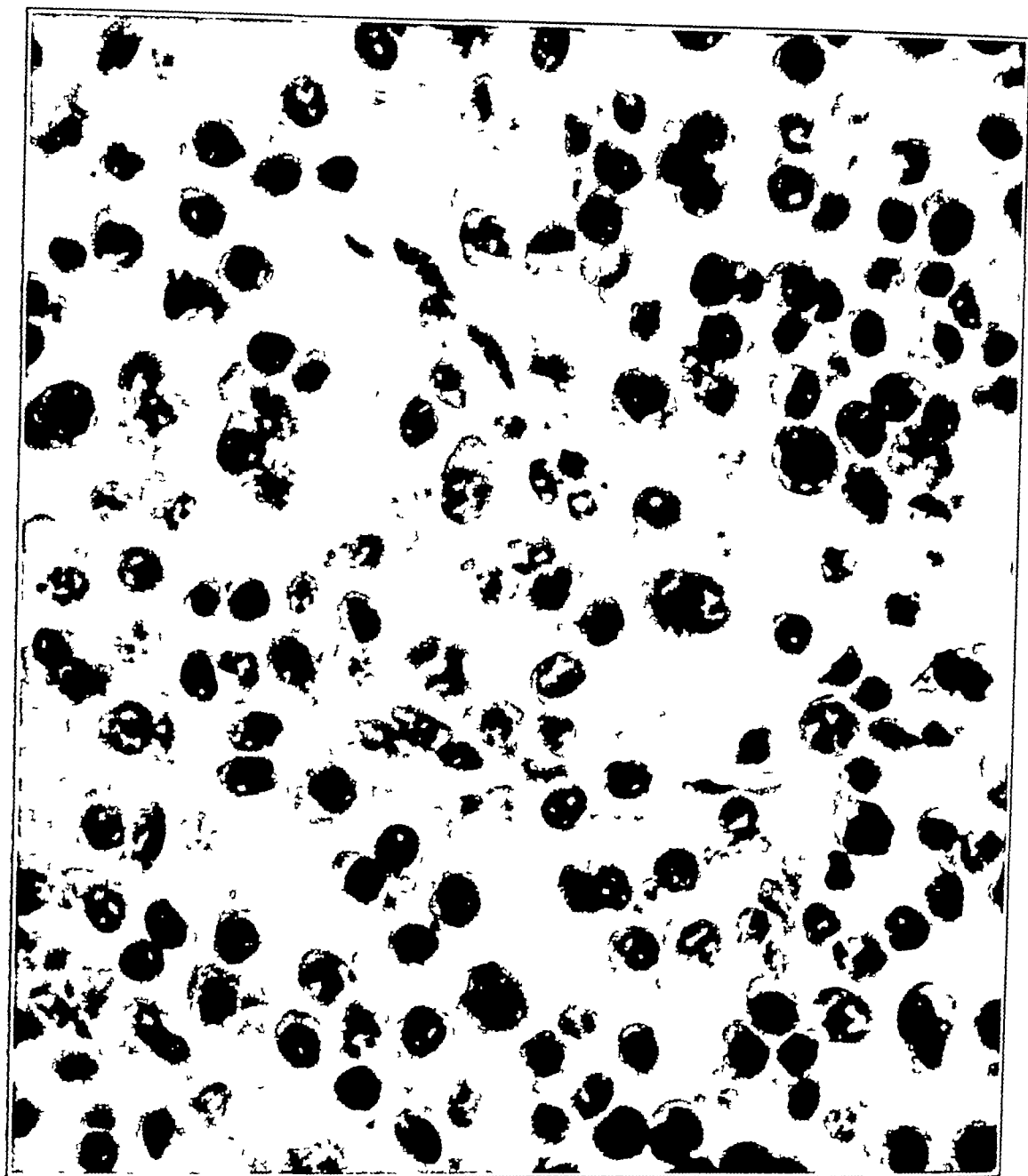


Fig 19 (case 2) —Typical plasma cell type Note the uniformity of chromatin arrangement in the nuclei

and spine, or of the ribs, sternum, clavicle and spine. Forty per cent of these patients have, in addition, either involvement of the skull or the extremities about the shoulder or pelvic girdles, beside involvement of the trunk. We have not found the extremities alone affected by the tumor in any proved case of multiple myeloma. In rare cases multiple involvement of the spine only, or of the ribs only, has been reported.



FIG. 6 (case 10).—Gross specimen of tumor in the shaft of the femur.

Exceptions are so rare that the statement that myeloma is always multiple and always involves the trunk is practically vindicated. It is confined for the most part to the sites of the red marrow.

The tumors vary in size from that of a pinpoint to that of an orange and more generally from that of a pea to that of a hazelnut. The patient may be made aware of such tumor by tenderness, pulsation, rare fracture or pathologic fracture. Occurs only a diffuse atrophy or so-called rickets which may not give evidence of tumor formation. (Aschoff

each nucleus a nucleolus is found. Within the nucleus, sparse chromatin in spokelike arrangement is spaced at the periphery. The nucleus is either globular, or more rarely, bean-shaped, and has a well defined nuclear membrane.

These cells, referred to most frequently as plasma cells, do not take the typical plasma cell stain by the Unna-Pappenheim or polychrome methylene blue technic, the perinuclear halo is almost always lacking, and the nucleus is slightly larger than the nucleus of the plasma cell.

A type of cell bordering on this description, found in nearly every case intermingled with the larger cells, is a smaller one from about 4 to 6  $\mu$ . It slightly resembles the lymphocyte in that the cell is poor in cytoplasm and the nucleus is relatively large in comparison with the rest of the cell, it is globoid and the chromatin, although sparse and of the same mural arrangement as the larger cells, appears more compact because confined in a relatively smaller space.

A frequent observation in the sections studied is the occurrence of apparent mitotic figures. The process is seen in many phases, and the frequency of its presence in the larger cells would seem to indicate that there is a relationship between this process and the multiple nuclei seen in larger cells.

Between these two types there are all stages of gradual transition and gradations, giving the impression that they are similar in derivation.

As for the so-called myeloblastic or myelocytic type of myeloma, we have repeatedly observed that concerning the same section, two authorities will differ between these two terms. Ewing, in cases 8 and 11 in our series, used the term myelocytic or myeloblastic, while Bloodgood used the term plasma cell type. In running through a series of twelve proved cases in rapid succession, one finds that these two cases do not stand out especially as atypical and fit in well with the so-called plasma cell type, although superficially, the nuclei do not appear to be as typically spokelike in arrangement. Many authors, in describing such cells in cases of multiple myeloma, are uncertain whether to class these cells in the plasma or myelocytic series (Berblinger, McCallum, Shennan, Schutz, Sexmuth, Klein, Stumm, Weber, Williams, Evans and Glynn), and some of these authors have thought that the apparent difference was due to fixing or staining methods.

In some cases, the differentiation was made on the basis of the oxidase reaction (Berblinger, Beck and McCleary, Vance, Warstat, Weinberg and Schwarz, Meiremet), and in other cases on the Unna-Pappenheim reaction for plasma cells (Aschoff, Hoffmann, Menne, McCallum and Neckarsumer). While the differentiation can thus be made in some cases, often it cannot be made by either oxidase reaction or by Unna-Pappenheim stain. Christian, in his study of six cases, believed that the myeloma cell is a transitional form not to be classed

A peculiar feature of some of the tumors is their tendency to decrease spontaneously in size, with disappearance and reappearance, as in a case cited by Thomas. While roentgen-ray therapy has been known to influence these tumors (Moore), this feature obscures the actual results. Perhaps this variability in size is to be associated with hemorrhage and the absorption of hemorrhage, as, on section, these tumors are frequently exceedingly vascular or hemorrhagic. This quality also explains the occasional pulsating and semifluctuant characteristics.

#### DEFORMITY

Deformity of the bone has long been recognized (since Kahler) as an accompaniment of multiple myeloma, but its distinctive peculiarities have not been sufficiently emphasized as is evidenced by the frequency with which this disease is confused with Paget's osteitis deformans, osteomalacia and von Recklinghausen's polycystic disease.

In cases of myeloma 60 per cent show thoracic deformity, and in the rarer instances in which this deformity extends to the extremities, it is confined to the regions of the girdle. Bowing of the tibiae as in Paget's disease, marked bending of the extremities as in osteomalacia and globose sites of malunion in the lower limbs that are found in von Recklinghausen's disease practically never occur in cases of myeloma. The deformities are peculiarly thoracic and their favorite sites are about the sternum and the spine.

At the sternum, in addition to tumor, there is often a sinking in at the angle of Ludwig, or more rarely, a "wavy" deformity of the gladiolus. Parasternally along the ribs and at the clavicles, multiple small tumor nodules may be frequently palpated, and this multiple involvement is so frequent (approximately 50 per cent) that we have termed it the parasternal rosary to call attention to its diagnostic importance.

In the spine, flattening of the lumbar curve, dorsal kyphosis, and actual telescoping of the spinal column due to infraction and collapse of the vertebral bodies occur commonly. In Marchwald's case there was a maximum shortening of 20 cm., while in a case cited by Kahler and one of our own there was nearly an equal amount. Scoliosis is not a rare observation.

These deformities of the trunk lead to a rather characteristic habitus or stance. The patient stands with protruding abdomen, his bulging lower ribs resting on the pelvic brim, his shoulders braced back and his feet set at a wide base to aid in maintaining his equilibrium. Fatigue and pain come on rapidly with standing. The patient walks with the utmost deliberation and caution, if indeed his affliction does not confine him to bed. In some cases the chin rests continually on the chest, giving rise to decubitus ulcers (Wallgren, P. Weber).





Fig 21 (case 7) —Portion of a tumor rich in stroma Typical chromatin arrangement of nuclei is again seen

In a restudy of malignant tumors of the bone, comprising a more recent series of cases in the same laboratory, we have found 33 per cent of pathologic fracture in metastatic tumors of the bone and 62 per cent in multiple myeloma.

While pathologic fracture is not infrequently the source of the first symptom of onset, it is less frequently recognized in itself as an initial sign of the disease. Wallgren's case (case 1) was diagnosed clinically as exudative pleurisy. At autopsy, fracture of the fifth rib was discovered, with a large subperiosteal hemorrhage. In our case (case 1) an early symptom was pain from fracture of the rib, which was only discovered a year later at this clinic by careful roentgen-ray study.

The distribution of fractures in this disease is unique. In other tumors of the bone (as shown by the studies of Bloodgood) pathologic

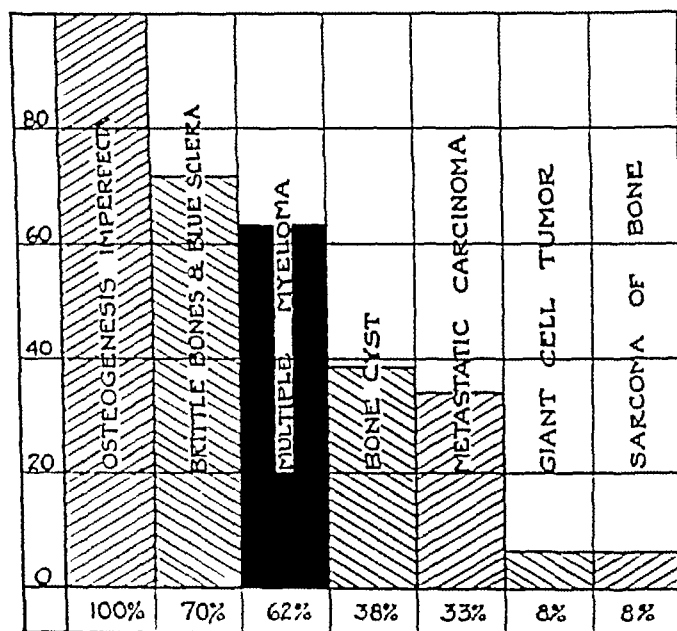


Fig. 9—Incidence of pathologic fracture in bone diseases prone to fracture, based on 1,040 cases.

fracture occurs almost exclusively in the long bones of the extremities. In contrast to this the principle sites for fracture in multiple myeloma are in the trunk, the prevailing location being the ribs (involved in over 50 per cent of the cases of pathologic fracture in myeloma). The clavicle and sternum are less frequently affected. In two of our own cases the clavicle was involved as it was in the cases of Howard and Crile, Symmers, Moore, Abderhalden and Rostoski, Cathcart, Bruce, Lund and Whitcomb, and McVerding. Fractures occurring in the sternum are described by Beck and McCleary, Weber, Seegelman, Zahn, Herz, and Williams, Evans and Glenn.

Often a striking feature of the fractures is their multiplicity. Although in other tumors of the bone repeated fractures are often

weakness in the form of general lassitude, sometimes marked by a loss of power in the legs adumbrating a gradual paraplegia. The patient's attention is first called to the malady by trauma, spontaneous fracture, the discovery of tumor or suddenly exacerbated pain brought on by some incident of muscular exertion. The complicating features of nephritis, gastric disturbances, or pulmonic changes may more rarely usher in the disease.

From this initial phase the patients pass on to a period marked by more continuous pains, by increasing deformities with kyphosis, tumor swellings, shrinking stature, multiple fractures and to paralysis with bedridden state. In some cases, the pulmonic symptoms become more acute and the nephritis more outspoken with anasarca and progressive cardiovascular changes.

Before this stage of advancing disease takes its fatal turn, a remission with temporary decrease or abatement in the intensity of the symptoms will frequently manifest itself, but in a short interval of time final failure sets in with cachexia and anemia. Flaccid paralysis ensues with decubitus, total incontinence and severe ascending urinary infection. Culminating in agonizing pains, the end comes on with terminal pneumonia, coma and death.

Not rarely, a patient may present an epitome of this entire range. In a case which we studied on the wards (case 1) there was, on admission, in addition to the marked skeletal deformity with shortening of stature, kyphosis, pathologic fracture and nodular tumors, a bronchitis and emphysema with asthmatic attacks, dilatation of the heart with systolic murmur, beginning paraplegia and strabismus, chronic nephritis with hypertension and hematuria, and increased metabolic rate and pronounced anemia. There had been an onset with an acute nephritis, and during the patient's stay in the hospital, there was marked remission of the disease. Later, when the patient returned home, there was an increasing paraplegia, recurring pain and an aggravation of all symptoms.

With such complexity in the clinical picture it is not surprising to find the initial diagnosis is often a mistaken one. Lumbago, spondylitis deformans, Pott's disease, nephritis, pleurisy, tabes dorsalis, Paget's disease, osteomalacia, osteitis fibrosa or visceral carcinoma with skeletal metastases are common errors in diagnosis. The symptomatology, otherwise misleading, is often clarified by beginning in the skeleton with both osseous and bone marrow destruction and tracing from these two fundamental changes in the skeleton on the one hand and in the hemopoietic tissue on the other, the various disease manifestations of multiple myeloma.

The tumor formation in the ribs may lead to pathologic fracture or to subpleural nodules and these to hemothorax, pleurisy or even

fracture it, as in a case described by Jellinek. Infraction and crushing of the vertebrae, particularly under strain or lifting are frequent. The various deformities that arise in this manner have already been referred to.

We think that cases in which fracture is described as preceding the disease as an etiologic factor (Anders and Boston) are subject to reinterpretation. There is no evidence at hand to substantiate preceding fracture in healthy bone as an etiologic factor in multiple myeloma, as has occasionally been demonstrated for giant cell tumor and sarcoma of the bone.

#### PULMONARY CHANGES

When the thoracic deformity of patients with multiple myeloma is marked, chronic bronchitis and emphysema are of common occurrence, averaging 55 per cent of the cases. The prevailing type of bronchial involvement is a diffuse persistent bronchitis of the mucopurulent variety, characterized by a productive or hacking cough. The debilitated and cachectic condition of these patients, the hypostatic pulmonic changes dependent on their bedridden state and the restricted alveolar ventilation brought about by painful respiration may be considered contributory factors to this bronchial involvement.

Second to bronchitis, emphysema is most frequently observed (Wallgren in five cases, Morse in two cases, McIntyre, Bence-Jones and Dalsympic, Ellinger, Weber and others). Dyspnea and asthmatic attacks are often accompanying features. In these cases, the anginal pains particularly emphasized by such violent expiratory efforts as sneezing and coughing, cause the patient to breathe shallowly with the chest held in a distended inspiratory state. Weakening of the alveolar walls consequent on nutritive changes makes emphysema a likely possibility.

Various forms of pleurisy have been reported by Senator, Sternberg, Herz, Caccini, Warstat, Kahn, Vance, Wells, Symmers, Morse, Austin, Beck and McCleary, McIntyre and Wallgren. In some cases, this has been described as fibropurulent (Herz), and occasionally as an empyema (Hansen, Oftedal). At autopsy subpleural nodules or indented fracture deformities of the ribs have been found in association with the pleuritic changes. Pulmonary tuberculosis has rarely been reported in patients with myeloma (Kahn, Austin, Wallgren).

In these various conditions of the lung there is a fatal progression—generally onward to a terminal pneumonia.

#### NEUROLOGIC OBSERVATIONS

Attacking the bony framework which otherwise serves as a natural defense for the nervous system the tumors of myeloma soon manifest themselves by an ensemble of neuralgic and neurologic symptoms. The most important of these is the paraplegia that follows the involvement

TABLE 2—*New Growth in the Bones, Tumor Formation Giving Rise to*

I Anemia		II Beuce Jones Bodies Formation		III Bone Destruction, Skeletal Deformities			
Resistance lowered	Associated achylia	Lower platelets	Associated nephritis	Thorax	Barrel chest	Kyphosis	Spine
Secondary infection (1)	Gastritis (2)	Hematemesis epistaxis (3)	Terminal enterocolitis (4)	Pathologic fracture	Bronchitis emphysema (2)	Paraplegia (3)	Cord compression Radiculitis (4)
				Decubitus and ascending genito urinary infection	Bedridden hypostatic pneumonia	Girdle pains	Gastro intestinal disturbances



to avoid unnecessary pain on motion and pathologic fractures is important. When fractures occur, the ordinary methods of treatment by fixation may be given, as pain is thus minimized and healing often accomplished. Morphine for pain, liver diet and tonics for anemia and inhalations for respiratory complications are helpful.

## SUMMARY

The history of multiple myeloma has been briefly sketched and the cases published since 1848 compiled. Males were found affected in 70 per cent of the cases, the age group from 40 to 70 predominated, and the geographic distribution found to extend to all parts of Europe, to North and South America and to Australia with members of the black

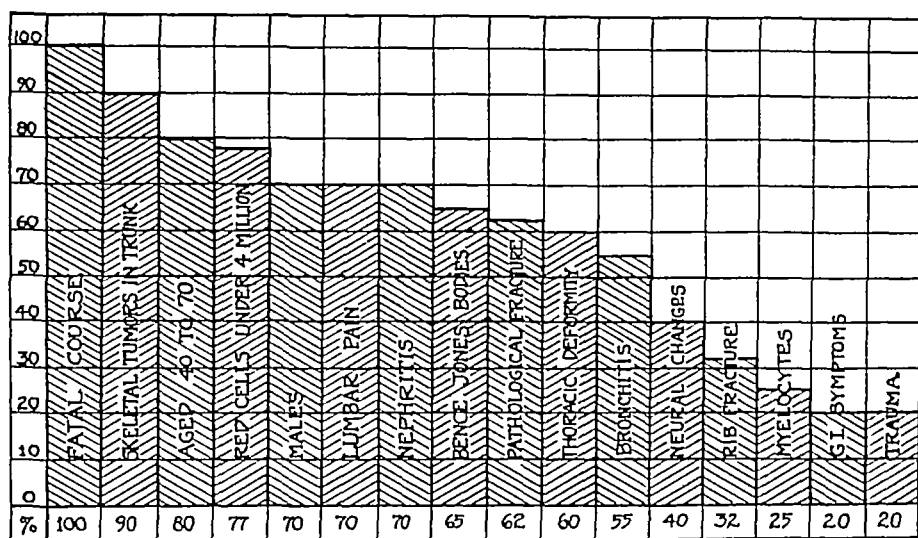
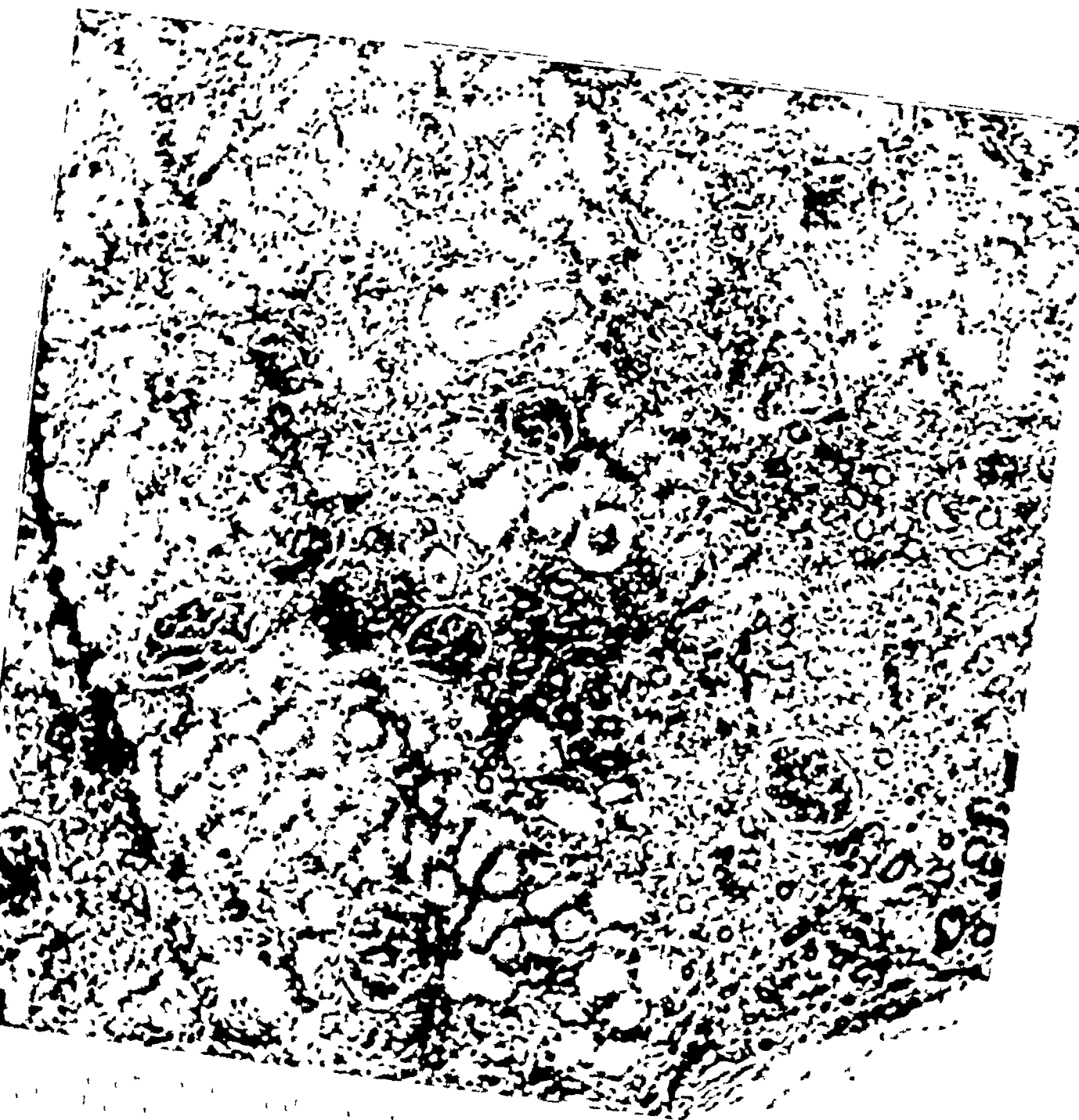


Fig. 23—Incidence by percentage of leading symptoms of myeloma

and yellow races included. Myeloma was found to constitute about 0.03 per cent of malignancy of all types, with the etiologic factors of heredity, trauma and infection playing little, if any, rôle in its production.

Among the clinical symptoms, intermittent rheumatic pains were found a leading symptom of onset, localized chiefly in the lumbar region with radiations to the legs and girdlelike sensations about the lower part of the thorax, aggravated by motion and typified in their course by insidious onset, sharp exacerbation, remissions and final agonizing termination.

Multiplicity of tumor involving the thoracic cage was present in over 90 per cent of the cases, the tumors being relatively small and elastic, with occasional pulsation, crepitation and regression. Skeletal deformity was shown to occur in 60 per cent of the patients characterized by a sunken sternum, "parasternal rosary," dorsal kyphosis, shortening of stature,





## REPORT OF CASES

CASE 1<sup>5</sup>—J W E, aged 40, white, a farmer, was admitted to the Johns Hopkins Hospital on Oct 21, 1926, complaining of "kidney trouble" There was a family history of cancer in one uncle He had suffered the usual ailments of childhood, having had typhoid at the age of 8 With the exception of frequent colds and asthma for the past three years, his health had been good Ten years before admission to the hospital, while he was lifting a heavy weight, a severe backache had started which had lasted several days Three years later, this recurred under similar circumstances Two years later, for the first time, an acute spontaneous pain occurred in the back Two years before admission, an operation had been performed for hemorrhoids, this was followed three weeks later by an attack of acute nephritis with hematuria, headache, palpitation and anasarca After the acute symptoms subsided, nocturia and pounding headaches persisted In March, 1925, on inadequate provocation, he fractured a rib Following this, there were dull aching pains between the shoulders radiating down his back and around his ribs From March to May, 1925, the patient remained in bed, with severe pains in the bones and muscular twitchings which made him feel as though he were being "drawn together" Roentgenograms taken at the time showed "cancer of the bones" During the past year he has noticed decrease in his stature and bending of his back He lost 20 pounds (9 kg) in weight

On physical examination, the patient presented a striking picture He was emaciated, pale and weak, with sallow complexion and labored respirations The arms and legs were of normal length He stood with feet wide apart, his normal lumbar lordosis had disappeared, and an upper dorsal kyphosis was present which allowed his chest to sink almost to the pelvis Small bony nodules were found over his right humerus, the inner end of the left clavicle and the right third rib The left eleventh rib was tender and easily misplaced The chest was filled with coarse râles, the respirations were wheezing, the heart was enlarged and the arteries were thickened The pulse rate was 90, the blood pressure 175 systolic and 100 diastolic The liver and spleen were palpable The patient weighed 125 pounds (56.7 Kg) The sputum was negative for tubercle bacilli The blood count revealed hemoglobin, between 35 per cent and 40 per cent (Sahli), the red count, between 1,600,000 and 1,900,000, and the white cell count, between 8,000 and 12,000 on five different examinations over a period of two weeks The differential count was normal with 70 per cent neutrophilic polymorphonuclears The nonprotein nitrogen in the blood was 34 mg per hundred cubic centimeters, the uric acid, 31.1 mg per hundred cubic centimeters, phosphates, 48 mg per hundred cubic centimeters, calcium, 10.8 mg per hundred cubic centimeters, and chlorides, 649 mg per hundred cubic centimeters The Wassermann test of the blood was repeatedly anticomplementary The excretion of phthalein was 55 per cent for two hours, the urine showed staphylococci and hemolytic streptococci The Bence-Jones test was positive on four different occasions (although often negative) Urinalysis also showed 3.2 Gm of serum albumin per liter, with red and white cells and granular casts present on microscopic examination The excretion of chloride in the urine on salt free diet was 5.5 Gm The vital capacity was reduced to 18 to 25 liters, the basal metabolic rate was plus 26

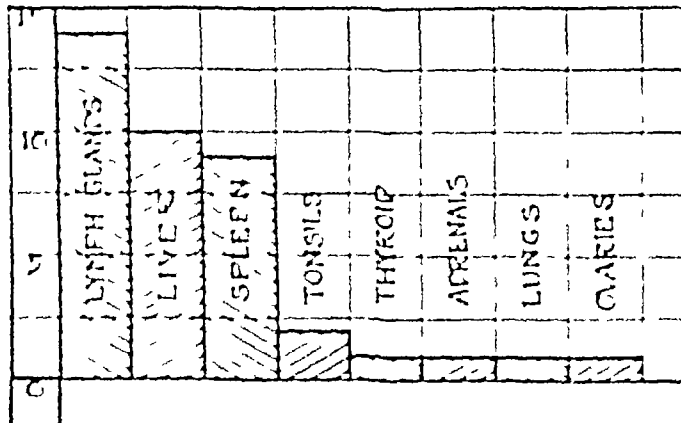
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5 This case is also referred to by Longcope *International Clinics* 2 91, 1927 Perlzweig, Debrue and Geschickter *Hyperproteinemia and Multiple Myeloma* J A M A 90 755 (March 10) 1928

Proch, Verca, A. V. Iazy and Koch, Hoffman, M. J. C., Sauer, Herzheimer, Shuman, Arnold, Madsen, Krudrevetsky, have reported metastases in the liver. Growths in the lymph glands were reported by Arnold, Christian, Lohrersch, Lungheer, Charles and Sangunetti, Harsbater, Lamberton, Devic and Perid, Micromet, Schale, Herzheimer, Steinberg, P. Weber and Bechtold.

More rarely other organs are affected: the tonsils (Shutz, Anders and Boett), the thyroid (Friedrich), the suprarenals (Bechtold), the ovaries (Herrick and Heikteen), and the meninges (Krudrevetsky).

The metastases, microscopically similar to the original tumor, are of the same connective formation in the gross, but rarely attain a large size (one of a walnut is the largest). When found they are generally multiple, unless apparently arising by extension from proximal bone.



Roentgen-ray examination showed multiple destructive lesions of the bones in the thorax, pelvis and skull with pathologic fracture of the eighth and ninth ribs and the clavicle on the right side.

The patient failed rapidly. Complete paraplegia developed with ascending urinary infection and anuria on the last two days. The temperature did not rise above 100 F.

At necropsy, the anatomic diagnosis was multiple myeloma involving the right clavicle and acromion, the seventh, eighth, ninth and tenth ribs on the right with pathologic fracture of the ninth rib and erosion of the seventh, eighth and ninth vertebrae, with softening of the cord at this level. The tumor masses were soft and variegated white and red. There was a fibrinous pleurisy on the right side. The liver was enlarged with fatty degeneration. There was cloudy swelling of both kidneys with bilateral pyelonephrosis and pyelitis. Cystitis and a mucous colitis were present. On microscopic examination the tumor was diagnosed plasma cell type multiple myeloma.

Microscopic examination of bone marrow showed evidence of meager stroma, rather compact homogeneous masses of plasmalike cells. Red blood cells were sparse. An occasional cell of the polymorphonuclear series was seen.

CASE 3—Mrs. E. W., white, aged 71, was referred to Dr. Bloodgood on June 20, 1926. She was seen in consultation with the complaint of tumor in the left axilla. There had been malignancy in both the mother's and father's family. The patient had had malaria at the age of 16. She was the mother of six children and had had two miscarriages. She had had hemorrhoids at the age of 61. The present illness dated back two years, at which time the patient had been operated on for a tumor in the left axilla. This tumor had been present for fifteen years, but four months before examination had begun to enlarge and cause pain. At the time of excision of the tumor, the diagnosis was old healed tuberculous glands. The incision broke down and in March, 1926, the patient complained of pain in the left shoulder with limitation of motion in the joint. The glands had not recurred. The pain continued, the patient lost weight and there was bronzing of the skin.

On physical examination, a mass was found in the right epigastrium which was painless. There was a pathologic fracture of the left humerus with evident tumor formation. Examination of the heart, lungs and pelvis was negative. The urine showed 3 plus albumin with many bacteria, but was negative for Bence-Jones protein. The blood showed red cells, 2,490,000, hemoglobin, 50 per cent (Sahli), white cell count, 5,800, with a differential count of neutrophilic polymorphonuclears, 53 per cent, lymphocytes, 37 per cent, large monocytes and transitional cells, 10 per cent. The Wassermann test of the blood was negative. The blood pressure was 140 systolic and 90 diastolic. The pulse rate was 86, the temperature, normal.

The roentgen-ray examination showed mottled areas in the left scapula, humerus, ribs and femur. A pathologic fracture was noted through the neck of the humerus.

Following a biopsy, the patient became progressively worse and died in coma.

At autopsy, soft tumor masses were found in the shaft of the humerus, in the head and neck of the scapula on the left. The ribs and sternum were involved by tumor and easily broken. The lungs and mediastinal glands were free from tumor. The liver showed fatty degeneration. The kidneys showed chronic interstitial nephritis. There were gallstones with a fibrotic gallbladder.



junction of the sternum and third left rib. Ulcerated areas were found over the right thigh and a fracture of the upper third of the right femur. The result of the examination of the heart and lungs was negative.

The examination of the blood showed a hemoglobin of 40 per cent, red cells, 3,352,000, white cells, 12,200, a differential count was not recorded. The urine was negative for Bence-Jones proteins.

The roentgenogram showed destruction at both ankles, left shoulder joint, left third rib and right upper femur with a healed fracture of the femur. The Wassermann test of the blood was negative.

At necropsy, the anatomic diagnosis was myeloma involving the femur with pathologic fracture of the left clavicle, sternum and left third rib. There was an old obliterating pleurisy.

Microscopic examination of the tumor mass showed more than the usual amount of stroma and a variation of the myeloma cell toward the myelocytic type, but with the plasma cell type much in evidence.

CASE 6—M. C., a colored woman, aged 37, was referred to Dr. Bloodgood on Dec. 21, 1921, with a complaint of pain in the back and left side. The patient's mother had died of pulmonary tuberculosis. The past history revealed the usual diseases of childhood with malaria in youth. She had been pregnant ten times and recently had had some leukorrhea.

The present illness began one year before examination with pain in the back and the left side. Three months before examination the pain was severe enough to force the patient to bed. She continued to be bedridden. A pathologic fracture and a marked loss of weight occurred during this period.

On physical examination, the patient showed marked loss of weight and tenderness over the lumbar region. There was a pathologic fracture of the neck of the right femur. The results of examination of the heart and lungs were negative. The spine did not show any abnormalities. The blood pressure was 130 systolic and 80 diastolic. The blood showed a hemoglobin content of 77 per cent, red cells, 4,250,000, white cells, 13,200 with a differential of 72 per cent polymorphic neutrophils, 13 per cent lymphocytes, with 15 per cent large mononuclears and transitionals. The urine showed a trace of albumin with white blood cells, red blood cells and casts. Bence-Jones bodies were found. A cystoscopic examination showed pyelonephritis, the phthalein appeared in seven minutes.

The roentgenogram showed bone destruction in the pelvis and right femur. Complete studies were not made.

The course was steadily downward, with marked loss of weight, fever and terminal pneumonia. The patient died on April 6, 1922.

At necropsy, visceral involvement was not found. There was a subpleural nodule on the posterior surface of the right lung. The anatomic and microscopic diagnosis was multiple myeloma of the plasma cell type.

Microscopic examination of the tumor mass revealed a typical but highly fibrous type of myeloma with great variation of the cell sizes.

CASE 7—W. H. H., a man, white, aged 55, was admitted to the Johns Hopkins Hospital on Sept. 3, 1921, with a complaint of pain in the lumbar region and legs. The family history was noncontributory. He had had the usual diseases of childhood, and typhoid at the age of 41, influenza at 53 and pneumonia at 55. He had suffered many years from nasal catarrh and headaches. There were many pigmented moles. The present illness began one month prior to admission with pain in the lumbar region following a second attack of influenza. Pain in the lumbar region persisted and radiated to the legs.

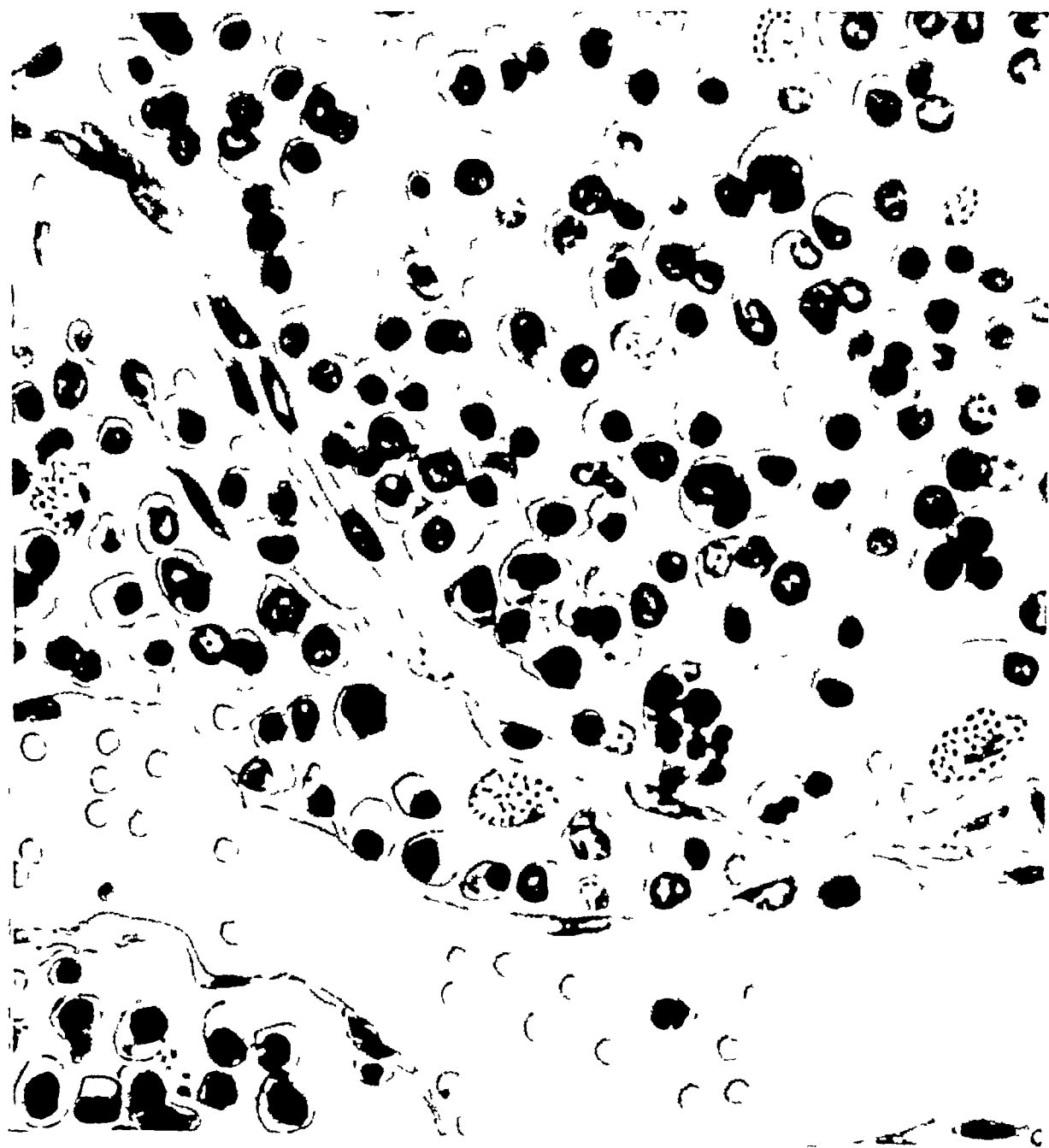


FIG. 15 (case 9).—Malignant cell in the small blood vessel. The photograph has been retouched to show accurately the chromatin arrangement in the nuclei, the presence of multiple nuclei cell and eosinophils.

Microscopic examination showed sparse reticulation, many thin walled blood vessels, and densely packed cells. The size of the cells varied from small cells with little cytoplasm to large multinuclear cells with a large amount of cytoplasm. The nuclei were typical, with mural arrangement of a sparse amount of chromatin and a central nucleolus.

CASE 9<sup>1</sup>—C M, a colored woman, aged 50, for ten years had had rheumatism and a cough in winter. One year before examination, she had had pain in the right hip and knee, followed by fracture of the right arm eight months later. Recently, there had been swelling on the head and fracture of the right leg.

Physical examination showed pallor and emaciation, false motion with pain of the right arm and leg, and tumor masses of the clavicles, the skull, the left scapula, and of the extremities and at the costochondral junctions.

The blood showed a hemoglobin content of 52 per cent, red cells, 3,548,000, white cells, 4,500 with a differential count essentially normal. The urine gave a 4 plus reaction to the albumin test with casts and Bence-Jones protein definitely present.

The patient failed rapidly, and at necropsy the anatomic diagnosis was multiple myeloma involving the femur, ileum, clavicle, sternum, skull and scapula with chronic nephritis, arteriosclerosis, and myomati uteri and healed tuberculosis of the lungs.

Microscopic examination showed sparse stroma and many blood vessels with walls lined by single endothelial cells (fig 5). The cells were three general sizes—a small dense cell, with the nuclear mass appearing solid but which on further examination had the same arrangement as the larger cells, a cell of medium size of the plasma cell type, and a larger, occasional giant cell with several nuclei.

CASE 10—B, a man, white, aged 44, was referred to Dr Bloodgood on Dec. 19, 1924, with a complaint of swelling and pain in the left knee. The family history was negative. In the past he had always had general good health. There was no history of gastric or urinary disturbances. The present illness began three years before examination with pain and swelling in the left knee. The pain was continuous, but the swelling intermittent. Six months previous to admission, the pain had disappeared. The swelling became permanent. The leg was useless and the patient began to use crutches. Two months before admission, there had been an onset of fatigue and weakness. There was history of trauma to the knee five years before. On physical examination, the patient showed evident loss of weight. The mucous membranes were of good color. The heart and lungs were normal. The left leg had been amputated through the middle of the thigh.

The results of analyses of the urine were negative and did not show Bence-Jones bodies. The blood showed a hemoglobin of 70 per cent, red blood cells, 4,480,000, white blood cells, 6,000, a differential count showed 70 per cent polymorphoneutrophils, 4 per cent eosinophils, 2 per cent basophils and 24 per cent lymphocytes. Excretion of phthalein was normal.

Roentgen-ray examination showed a central tumor in the shaft of the femur with bone destruction and perforation of the bone shell and mottling of the marrow cavity.

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<sup>1</sup> This case, no 9, on file in the surgical pathological laboratory of the Johns Hopkins Hospital has been reported elsewhere by Hamburger and by McCallum. A summary only is included here for completeness.





There were tumor masses over the tenth, eleventh and twelfth dorsal spines. There was an elevation over the parietal bone and tenderness over the fourth rib on the right. The lungs were normal. The heart was slightly enlarged to the left and a soft systolic murmur was heard at the apex. The liver and spleen were not palpable. The rectal sphincters were relaxed. The blood picture showed hemoglobin, 50 per cent, red blood cells, 2,432,000, white blood cells, 10,760, the differential count showed 66 per cent polymorphonuclears, 28 per cent lymphocytes, 6 per cent mononuclears and transitionals. The Wassermann test of the blood was negative. The examination of the urine showed 3 plus albumin and the test for Bence-Jones bodies was positive. Microscopically, the urine showed red blood cells, white blood cells and casts. The excretion of phthalein showed a total of 9 per cent for two hours on one occasion and 18 per cent on another. The Mosenthal test showed fixation of specific gravity. Gastric analysis did not show any free hydrochloric acid, but showed a combined acidity of 6 degrees. The guaiac test for occult blood was negative. The percentage of acidity was 0.02. The blood chemistry studies showed nonprotein nitrogen from 70 to 80 mg per hundred cubic centimeters with a carbon dioxide combining power of from 18 to 27 volumes. Chlorides were from 585 to 593 mg per hundred cubic centimeters, creatinine, 3.3 mg and 3.8 mg per hundred cubic centimeters and sugar 0.083 mg per hundred cubic centimeters.

The roentgen-ray examination showed multiple involvement of the skull, humerus and femora. The basal metabolic rate was minus 4.

The patient did not remain in the hospital. Biopsy was not obtained.

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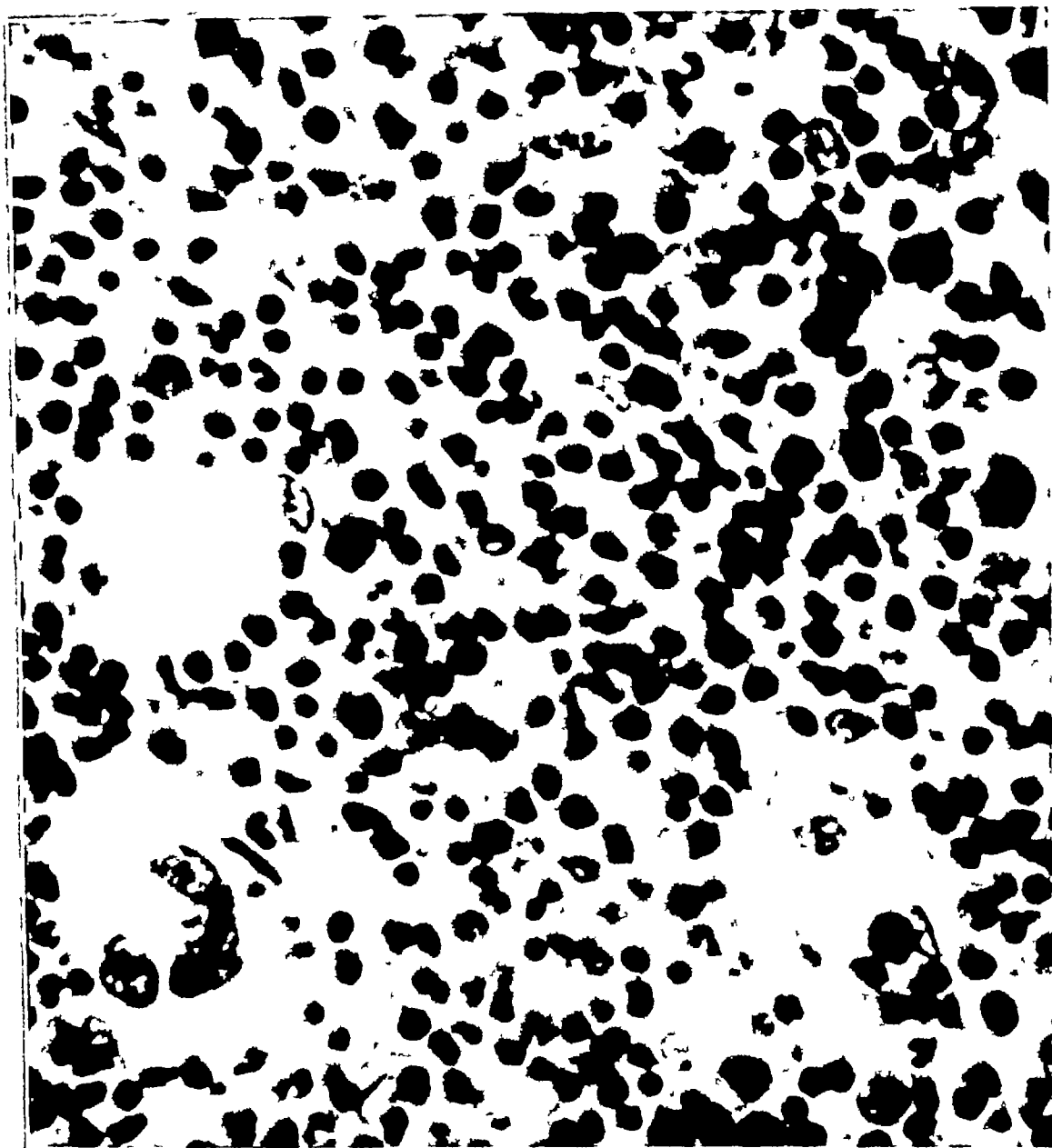


Fig. 20 (case 3) --Photomicrograph stained with polychrome methylene blue. Note the occurrence of giant cell and numerous small cells which in the picture could be taken for the lymphocytic type of myeloma cell but which under the microscope are seen to be the typical plasma cell type.

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as either plasma or myelocytic in type. Wallgren, in the study of thirteen cases, came to a similar conclusion.

As a rule, the myeloma tissue is rich in blood vessels. These are thin walled and lined with a single layer of endothelium (fig. 15). The blood vessels often have about them thin strands of fibrous tissue, although elsewhere in the tumor there is a noticeable lack of intracellular substance with a few fine fibrils here and there. There is often profuse hemorrhage into the tumor, and in almost all cases, there is a tendency for the tissue to be pervaded by red blood cells. Fat cells, giant cells and eosinophils are of common occurrence in myeloma tissue and in most instances, are more numerous at the outskirts of the tumor, being the surviving cells of normal bone marrow.

The myeloma nodules are only apparently circumscribed, and microscopically, it is hard to tell where the tumor begins or ends. The growth appears to bring about a direct eating away of the bone and the cells can be seen surrounding atrophying spicules of bones as if they were responsible for the disappearance of the osseous tissue (fig. 22). There appears to be a slight bone formation surrounding the tumor in earlier stages, which would account for the paper-thin bone shell often found. In other cases, the myeloma borders directly on the periosteum or infiltrates into adjacent tissue.

Only in rare instances do myeloma cells enter the circulation, in a manner so characteristic of the myeloblastic, myelocytic or lymphatic leukemias. These cells do not commonly pervade the hemopoietic tissue, such as the lymphocytes crowding into spleen and lymph glands in lymphosarcoma and lymphoid leukemia, despite the fact that in a small percentage of the cases, metastases are found in the liver and spleen. There is no change of the differential count in the sense in which one finds it in leukemia, nor is there the widespread crowding out of normal blood cell elements that one finds in the severe bone marrow diseases of aplastic anemia, and the blood does not lose its regenerative elements.

From this it would appear that the myeloma cell is not of the circulatory variety, but is peculiarly a marrow cell, restricted to some marrow function. Of the infectious or neoplastic nature of the disease of multiple myeloma, one can only say that the infectious or neoplastic nature of all tumors has neither been proved or disproved.

#### CLINICAL COURSE AND DIAGNOSIS

A brief turn in survey of the more characteristic features of multiple myeloma may serve to unify them into a more composite clinical picture and emphasize the typical course of the disease.

The onset is most often insidious, with indefinite wandering, rheumatic pains predominantly about the back and loins, or with progressive

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Fig 22 (case 4) —Low power field showing the apparent erosion of bone by the invading tumor

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emphysema. Again, mere deformity of the ribs with accompanying pain and shallow respiration may lead to emphysema and bronchitis. The skeletal deformities in the spine are responsible for shortening of stature and compression of the spinal cord. This neural involvement in the form of radiculitis may give girdle pains and gastro-intestinal disturbance, or in the more ominous form of a paraplegia give incontinence and ascending urinary infection with pyelonephritis, the consequent bed-ridden state resulting in decubitus and hypostatic pneumonia.

On the other hand, the destruction of bone marrow with anemia is followed by lowered resistance and a tendency to secondary infection. A lowered platelet count makes these patients prone to hemorrhage and epistaxis. More theoretically, an achylia associated with the anemia may lead to gastritis. The excretion of Bence-Jones bodies apparently following on bone marrow disease goes hand in hand with a chronic nephritis which in turn makes for a terminal enterocolitis.

In this way, the disease picture in all its phases, as traced in table 2, can be shown to have its origin in skeletal tumors.

In lack of a characteristic onset, we must be on the lookout for presumptive evidence of the disease. Of the aggregate of signs and symptoms described, what are the outstanding characteristics which constitute such presumptive evidence?

1 Foremost in the series stands multiple involvement of the skeletal trunk in an adult. Spinal deformity should not be examined without including in that examination the ribs and the sternum. If this had been done in nearly every case in the series studied in which a diagnosis of spondylitis deformans or Pott's disease was made, the correct diagnosis of malignancy, at least would probably have been hit upon, and in all likelihood myeloma itself diagnosed. Deformity of the spine, the parasternal rosary of tumor nodules, bulging and deformity of the ribs—these indicate multiple involvement of the trunk and are characteristic of the disease.

2 Occurring less frequently, but even more typically peculiar to this disease, is the pathologic fracture of a rib. Pathologic fracture of a rib in an adult is ample presumptive evidence for suspecting myeloma. In no other disease does it occur with a semblance of the frequency found in this condition.

3 The outstanding feature detracting from the diagnostic value of Bence-Jones bodies in myeloma is the failure to carry out this test as a routine in bone disease and tumor of the bone. This test is so simple, implying watching for an early precipitate when the usual test for albumin is carried out by slow heating, that it should not be omitted.



# PERFORATION OF THE DIAPHRAGM

## THE RESULT OF INTRA-ABDOMINAL SUPPURATION

### REPORT OF UNUSUAL CASES \*

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Ordinarily the diaphragm is considered an efficient barrier between the abdominal and pleural cavities, even in cases of suppuration. While infection may spread in either direction by way of the lymphatics, extension by loss in continuity of the diaphragm is rather unusual and is particularly uncommon in cases of acute generalized suppurative peritonitis. The following cases briefly illustrate three different types of intra-abdominal inflammation responsible for intrapleural suppurative conditions.

#### REPORT OF CASES

CASE 1—R G, aged 44, had had a hysterectomy and a right salpingo-oophorectomy performed for a tubo-ovarian abscess which involved the tip of the appendix. Twenty-one days later, after a febrile course, a right perinephritic abscess was opened and drained. Intermittent pain persisted in the right side. Dulness developed at the base of the right lung, accompanied by an irritating, nonproductive cough. Later, a moderate amount of foul-smelling, purulent material was expectorated. The patient died on the thirty-sixth day following the first operation and fifteen days after the perinephritic abscess was drained.

The important points at autopsy were as follows. The perirenal tissue surrounding the right kidney was deeply congested and showed a small amount of seropurulent material. Between the upper pole of the kidney and the liver was a small quantity of pus. This extended over the surface of the liver, just anterior to the right lateral ligament. Passing upward, it perforated the right coronary ligament and formed a second abscess in the space between the diaphragm, the extraperitoneal portion of the liver and the folds of the coronary ligaments. This abscess contained about 60 cc of thick yellowish-white pus.

The base of the right lung adhered to the dome of the diaphragm by a fresh plastic exudate, 1 mm in thickness, that was easily separated. On separation, the dome of the diaphragm "bulged" upward and showed a small perforation about 2 mm in diameter at its highest point, from which a thick yellowish pus exuded. Immediately overlying this diaphragmatic perforation was a corresponding opening in the base of the right lung, from which a similar material also exuded on pressure. This perforation in the lung was surrounded by a consolidated area of irregular shape, roughly 5 by 7 cm. On section, it was found to contain a small abscess cavity about 1 cm in diameter, just beneath the pleura.

CASE 2—S J H, aged 40, about four weeks before admission to the hospital, complained of pain in the epigastric region, unassociated with nausea, vomiting, rise in temperature or pulse rate. The following day the pain became more or less localized in the right hypochondriac and iliac regions, but abdominal rigidity

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\* From the Laboratory of the Samaritan Hospital

as a routine in diseases of the skeleton. The albuminoid bodies are presumptive evidence for this disease. Their true diagnostic value, however, will not be known until this test is more applied in skeletal disease.

4 Although backache and radiating rheumatic pains are commonly found in myeloma, backache is sufficiently widespread clinically almost completely to nullify the diagnostic importance of this symptom. If in realization of the possibility of tuberculosis, metastatic carcinoma, sarcoma or myeloma of the spine, however, the clinician elicits a history of early compression of the cord (such as beginning loss of sexual potentia, difficulty in starting urination, or loss of power in the legs), this type of backache, exacerbated by movement, with radiating pains and associated signs of early paraplegia should be suggestive of multiple myeloma.

5 In some instances, an otherwise inexplicable and increasing anemia of the primary type will lead to roentgen-ray study of the bones when the facilities are available. Under these conditions, the possibility of multiple myeloma should be considered.

6 Finally, although adequate information is still lacking on this point, the presence of a chronic nephritis with nonprotein nitrogen retention and low blood pressure should arouse suspicion. In such cases, the urine should be tested for Bence-Jones bodies.

What in itself would not be evidence of conclusive diagnostic nature assumes through its corroborative association with similar evidence a diagnostic value of the first order. Thus, taken in pairs, triads or collectively as a group, the six conditions of (1) multiple involvement of the skeletal trunk in an adult, (2) pathologic fracture of a rib, (3) the excretion of Bence-Jones bodies, (4) characteristic backache with signs of early paraplegia, (5) an otherwise inexplicable anemia and (6) chronic nephritis with nitrogen retention and low blood pressure are of cardinal diagnostic importance for multiple myeloma.

The majority of cases of myeloma fit into a syndrome, embracing several of these salient features of the course of the disease which has been described.

#### PROGNOSIS AND TREATMENT

The prognosis is uniformly unfavorable, the average duration of the disease being about two years after the date of recognition. The longest duration of any proved case is five and one-half years (Wallgren, our case 1). The duration of the disease appears to be uninfluenced by treatment, although roentgen-ray therapy has been reported as bringing about remissions, however, as we have pointed out, remissions occur spontaneously. With no proved case reported as cured it is evident that palliative symptomatic treatment only is available. Nursing care

with a dirty yellowish exudate. Both tubes were intensely congested, but free pus could not be "milked" from the patent fimbriated ends. On the anterior surface of the liver were two softened depressed areas, irregular in outline, produced by collections of inspissated pus. A thin film of pus covered the surface of the liver. The stomach was much distended and filled with a turbid, brownish fecal fluid. In the left dome of the diaphragm was a ragged ulcerated area, about 7 cm in extent. In the center of this was a perforation about 2 cm in diameter.

The left side of the chest was filled with a brownish, turbid, foul-smelling fluid, completely filling the left pleural cavity, compressing the lung and forcing it closely against the mediastinum. Fluid could be made to flow back and forth through the diaphragmatic opening, as the lung was forced down into the fluid.

#### COMMENT

Perforations of the diaphragm practically always result from subphrenic abscesses. These in themselves are not particularly uncommon, but perforations occur, probably, in less than one third of the cases. Lang,<sup>1</sup> in a series of 173 cases, found 67 perforations, or 35 per cent, while Martinets,<sup>2</sup> in 138 subphrenic abscesses found only 33 perforations, or 25 per cent.

The site of the perforation varies, of course, with the situation of the abscess. According to Barnard,<sup>3</sup> abscesses may occur in six locations: four intraperitoneal and two extraperitoneal. The commonest abscess is probably the right anterior intraperitoneal, between the convexity of the right lobe of the liver and the dome of the diaphragm and between the falciform and right coronary ligaments of the liver. Subphrenic abscesses on the left side occur less frequently, although the left anterior intraperitoneal, corresponding to the pouch of the left kidney, seems to be second in order of frequency. It usually results from suppuration of the left lobe of the liver or a perforated gastric ulcer. The third commonest site is the right extraperitoneal, in the uncovered space between the coronary ligaments of the liver; such an abscess is almost always a result of intrahepatic suppuration. The right posterior intraperitoneal location, corresponding to the pouch of the right kidney, is also a frequent location for subdiaphragmatic abscess. Large quantities of pus may collect here before emptying into the general peritoneal cavity or right anterior intraperitoneal space of Barnard. Abscesses in either of these locations most frequently result from appendical or pelvic inflammatory conditions. The left posterior intraperitoneal abscess is rare and confined to the lesser peritoneal cavity. The left extraperitoneal abscess of Barnard is located near the left kidney, and like the left posterior intraperitoneal abscess, rarely occurs.

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1 Lang, quoted by Osler and McCrae. *Osler's Modern Medicine*, ed 3, Philadelphia, Lea & Febiger, 1925, vol 3, p 944.

2 Martinets, quoted by Osler and McCrae (footnote 1).

3 Barnard. *Brit M J* 1 371, 1908.

and pathologic fracture with an incidence of 63 per cent, affecting the ribs most frequently

Bronchitis and emphysema associated with thoracic deformities was found in 55 per cent of the series, followed by a terminal pneumonia in a majority of these instances

Neurologic involvement secondary to bony change was noted in 40 per cent of all cases, with radiculitis and paraplegia of the extremities predominant features

Bronchitis and emphysema associated with thoracic deformities was emphasized as a feature in two thirds of the patients with myeloma and the almost constant association of Bence-Jones bodies in the urine with this condition was pointed out

Among the less common manifestations of the disease were noted gastro-intestinal disturbance and metastatic involvement of the lymph glands, liver and spleen

Bence-Jones bodies were found to be excreted in 65 per cent of the cases and the simple laboratory tests for their demonstration recapitulated. The occurrence of these bodies in the urine of patients suffering from other bone diseases and diseases of the hemopoietic tissues was pointed out and a list of the cases given

The degree and nature of the anemia, characteristic of myeloma, was described and the various pathologic changes in the white blood cells enumerated

The peculiarity of the roentgen-ray observations in this disease with multiple punched out areas of bone destruction occurring primarily in the trunk and less frequently in the skull and proximal ends of the extremities was indicated. The possibility of rare metastases to the lung and subpleural nodules simulating pulmonic involvement was also mentioned

The uniformity of the microscopic picture in myeloma was emphasized and evidence cited that there is probably but a single type of marrow cell occurring in various stages of development in all cases

Lastly, a composite clinical picture of the disease entity of multiple myeloma was sketched with the original tumors of the bone marrow shown responsible by bone destruction on the one hand, and marrow changes on the other, for all the various clinical and pathologic changes described

Six cardinal features of myeloma were pointed out (1) multiple involvement by tumor of the skeletal trunk, (2) pathologic fracture of a rib, (3) Bence-Jones bodies in the urine, (4) characteristic backache with signs of early paraplegia, (5) an otherwise inexplicable anemia and (6) chronic nephritis, nonprotein nitrogen retention and low blood pressure

# ACUTE APPENDICITIS

WITH A REPORT OF ONE THOUSAND CONSECUTIVE CASES\*

E P QUAIN, M D

AND

R H WALDSCHMIDT, M D

PISMARCK, N D

This contribution to the subject of acute appendicitis is based on a study of 1,000 consecutive cases in which operation was performed by members of the Quain and Ramstad Clinic, Bismarck, N D, from November, 1919, to September, 1927. The report, submitted herewith in tabulated form, has been compiled by one of us (R H W) after a careful review of our clinical histories. It is hoped that the results obtained by our particular methods of treatment may be of some interest and use to those who may wish to make a larger review of the whole subject of acute appendicitis. It should be stated that the report is submitted, not in any spirit of superior wisdom or skill, but rather with a sense of humility because we have so often failed to save human life. A study of the report will demonstrate that with better surgical judgment there would have been fewer deaths.

The lessons in diagnosis that we gained and the problems of post-operative management that we encountered in this series will not be mentioned, but the more important features of the operative technic and the final results will be discussed briefly.

From a study of recent publications on acute appendicitis—fewer now than ten or fifteen years ago—it is evident that as yet not all surgeons follow the same tactics in combating the disease. It is evident, also, that there has not been any abatement in the frequency or in the mortality of the disease. Indeed, a few articles have been presented by medical statisticians to prove that in the past few years there has been an increase in the mortality rate from appendicitis in this country. The reasons for this have not been satisfactorily explained. Whether the increase is real or only apparent, we must leave without discussion. The fact that one cannot successfully prove the statement false should be a matter of serious consideration to all who are actively trying to reduce the mortality of appendicitis.

Recently collected figures from the Bureau of Vital Statistics indicate that about 25,000 people die annually in the United States from acute

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\*Read at the Sectional Meeting of the American College of Surgeons, Duluth, Minn., Nov. 18, 1927.

Special blood chemistry studies by Dr Perlzweig<sup>6</sup> revealed a refractive index of 1.3610 (normal 1.3450 to 1.3500), total protein, 12.32 (normal 6.5 to 7.5), albumin, 0.23 (normal 4.0 to 5.5), globulin, 10.11 (normal 2.0 to 2.5), fibrin, 0.79 (normal 0.20 to 0.30), and an albumin to globulin ratio of 12/88 or 0.13 with the normal 75/25 to 55/45 or 3.0 to 1.22.

Roentgen-ray studies showed multiple involvement of the skull, ribs, spine, clavicles and the long bones of the upper extremities by rarefied and small punched out areas with fracture of the eleventh left rib.

The left femur was examined surgically and showed a friable, highly cellular mass beneath the cortex. A portion removed on microscopic examination showed multiple myeloma of the plasma cell type (fig. 19).

The course in the hospital showed symptomatic improvement with disappearance of the respiratory difficulty and a fall in the blood pressure from 170 systolic and 102 diastolic to 125 systolic and 90 diastolic. The albumin in the urine decreased but did not disappear. The patient was discharged with the underlying disease process unaltered.

Microscopic examination of the bone marrow showed little stroma, solid masses of tumor cells both of plasma cell and small lymphoid cell varieties, many bone marrow eosinophils and cells of the early myelocytic series, many giant cells of the epulis type with the plasma cell type predominating.

CASE 2—C. D., a man, white, aged 51, was admitted to the Johns Hopkins Hospital on Jan. 21, 1925, with a complaint of pain across the back and the right side. The family history was noncontributory. He had had the usual diseases of childhood including scarlet fever. The past history also showed typhoid fever, gonorrhea and alcoholism. The patient had suffered with constipation and had had hemorrhoids fifteen years before admission to the hospital. There was nocturia and complaint of gastric disturbances. He was 66 pounds (29.9 Kg.) under his best weight.

The onset of the present illness was eighteen months before admission and occurred with rheumatic pains in the right shoulder following on a gradual loss of weight extending over a period of four years. Two and one-half months before admission, he developed a sharp pain in the right side while pitching horseshoes. Rapid loss of weight and strength followed with anorexia and swelling of the right clavicle and marked weakness of the legs.

On physical examination, there was emaciation and weakness with a definite icteric tinge to the sclerae. Swelling was present over the middle of the right shoulder, over the ninth and tenth ribs posteriorly and over the clavicle on the right side. The heart and lungs did not show abnormalities, the peripheral vessels were thickened and the blood pressure was 110 systolic and 85 diastolic. The abdomen was protuberant, the liver was palpable. There was marked weakness of the lower extremities with hyperactive knee and ankle jerks. The Oppenheim and Babinski reflexes were positive on both sides. The prostate was enlarged. The clinical impression was carcinoma of the prostate with skeletal metastases.

The blood showed hemoglobin, 55 per cent (Sahli), red blood cells, 3,224,000, white blood cells, 6,080 with the differential count showing 2 per cent myelocytes. The Wassermann reaction was negative. The urine, which was essentially normal on admission, showed albumin, red and white blood cells and casts when a retention catheter had been used following the development of a paraplegia. Examination for Bence-Jones bodies was repeatedly negative.

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6 Perlzweig (footnote 5, second reference)

adherent to surrounding structures. In some instances, considerable exudate was present. A small temporary drain was inserted after appendectomy in all such doubtful cases. This drain was removed the next day, when the appearance of the wound, or culture taken at the time of operation, showed that there was no infection. A few patients in this group had a remission of symptoms when first seen and for that reason were not operated on until two or three days later, usually after a recrudescence of pain. Subacute and interval cases are not included. There were 551 cases in this group, with two deaths.

When the infection was believed to be distinctly localized, either as a walled-off abscess, or definitely confined to the vicinity of the appendix, the surgeon classified the case as appendicitis with abscess. This group included 289 cases, with seven fatalities.

The remaining 160 cases were placed in the class of appendicitis with progressive peritonitis, because there was no question at the time of operation as to the free and spreading infection. Eighteen of the 160 died, yet the cause of death in some of these was only remotely due to appendicitis, as will be explained later.

Discrepancies have no doubt occurred in our efforts to differentiate "abscess" or "localized" peritonitis from "progressive" peritonitis. It is sometimes difficult to judge correctly and quickly whether one is dealing with a large localized infection, or with a free and spreading peritonitis. Practically, it is unimportant, and no time or effort should be wasted in trying to settle the question. The main surgical treatment is the same in the two conditions, and the operative technic later described has been followed in both classes of cases.

All patients with acute appendicitis received in our service were operated on at once after diagnosis was made and consent was obtained, with two exceptions. In one case, consent to the operation was withheld, in the other, the patient was moribund. Both patients died and their cases are not included in this report. A small number were first seen when the attack was subsiding. In these, interval operation was usually made—which excludes them from present consideration.

#### METHOD OF OPERATION

Some years ago we attempted to follow a different line of treatment, based on the recommendation of Dr. Ochsner, in cases in which an abscess was forming and in which the infection appeared to be localized. This plan was abandoned after several unfortunate experiences and after learning of the excellent results obtained by Knott who reported several hundred cases of abscess in which immediate appendectomy had been performed with a hitherto unheard of low mortality. It has been our practice, therefore, during the entire time of this report, to hurry the

On microscopic examination, the tumor was diagnosed multiple myeloma of the plasma cell type. The tumor tissue was particularly homogeneous in type with an occasional large myeloma cell among the masses of the more typical plasma cell type. On the outskirts of the tumor, there was much hemorrhage. Stroma was found only about the blood vessels.

CASE 4—C F T, aged 66, a man, white, was admitted to the Johns Hopkins Hospital on Sept 9, 1922, with a complaint of weakness. The family history was unessential. He had had typhoid fever in boyhood with some polyuria and nocturia in the past few years. The present illness began ten months previous to admission with bulletlike pains of short duration in the left side following an attack of influenza. The patient began to feel weak about the waist and was confined to bed. Loss of weight was rapid (70 pounds [31.8 Kg] in nine months). Recently, there had been epigastric discomfort.

On physical examination, there was evident loss of weight, marked weakness and some dyspnea. The trachea was deflected to the right, the lungs did not show descent at the bases and the percussion note was emphysematous. The peripheral blood vessels were leathery, the blood pressure was 104 systolic and 62 diastolic.

The liver was enlarged and its edge palpable. The spine was rigid in the lumbar region with thoracic lordosis and lumbar scoliosis. There was tenderness over the third and fourth lumbar vertebrae. The blood showed a hemoglobin of 40 per cent (Sahl) with 2,168,000 red cells, a white cell count of 11,800 and a normal differential count. The Wassermann reaction was negative. The urine showed 1 plus albumin and a positive reaction for Bence-Jones proteins. Cystoscopic examination revealed pyelitis on the left side. Phthalein excretion was 50 per cent for two hours.

The roentgen-ray examination showed multiple tumor involvement of the spine, chest and pelvis. The clavicle and first rib on the right were expanded with tumor, and the femora were involved at their upper ends.

Following the cystoscopic examination the patient became febrile and confused. He died with a terminal bronchial pneumonia. The temperature was 105 F.

At autopsy, the anatomic diagnosis was multiple lymphoid myeloma involving the vertebra, sternum, ribs and femora, terminal bronchial pneumonia, acute splenic tumor, chronic nephritis, with fresh multiple hemorrhages along the entire genito-urinary tract, multiple abscesses of the kidney with healing perirenal abscess, serofibrinous pleurisy, strawberry gallbladder and internal hemorrhoids.

Microscopic examination of the tumor showed finely reticulated stroma between eroded masses of bone spicules filled with plasmalike cells intermingled with large cells of the same variety. Many small blood vessels were seen permeating the reticulated cellular masses. Occasional giant cells of the epulis type were seen, together with masses of the small variety of cells.

CASE 5—A G, a man, white, aged 71, was referred to Dr Bloodgood on April 27, 1922, with a complaint of sciatic rheumatism. The family history was noncontributory. The past history revealed failing health for the past twenty years, with bilateral "rheumatism" of the lower extremities for the past fifteen years. The present illness began with a pathologic fracture one year before examination which involved the upper third of the right femur. The patient was treated for six months, poor results were obtained.

On physical examination, there was marked loss of weight and weakness. There was a pigmented nodule over the left clavicle and a raised area at the



Before the peritoneum is opened, when pus is expected, the exposed tissues are covered with pads in order to minimize contamination of the wound. By protecting the wound in this manner, a few sutures may safely be placed in clean tissues, with separate instruments, at the completion of many operations, even after pus has been found and evacuated.

The practice of holding up the edges of the peritoneum with forceps during the removal of an infected appendix (or any other operation) is a bad habit. Harmful bruising of the serosa is unavoidable.

After an abscess or infected area is opened, the exudate is promptly aspirated and the cavity gently cleansed. Too careful "walling off" of the infected area by the introduction of gauze pads will do more harm to the peritoneum and to the patient than the simple and quick withdrawal of the gross exudate by suction and trusting the rubber drains later to undo any possible spreading of the infection during the operation. When retraction of omentum, cecum or intestine is required, a smooth metallic spatula in a steady hand does the least damage.

The index finger is next introduced to locate the appendix. If the appendix is hard from infiltration or distention, or presents a large segment into the cavity, it is easily found. But if the appendix has been gangrenous for some time, has become soft and collapsed, or is embedded some distance away from the main pus cavity, it may tax the most experienced finger to determine its location and to liberate the sloughing remains without doing too much violence. The exploring finger must first be able to tell where the appendix is not. This is concluded from the comparative softness of the wall of the abscess and from the easier give in the surrounding tissues. As soon as the location and direction of the appendix is determined, it is gently dissected free by the same finger. Whenever possible, instruments should be avoided for this purpose. When the finger fails to locate the offending organ, a gentle traction of the wound will usually suffice to expose the head of the cecum, from whence come the required landmarks. Traction should not be made on the cecum nor on any other viscus. Violation of this rule may provoke destruction of the protecting infiltration, and dissemination of infection.

After the appendix is liberated sufficiently, the meso-appendix is tied off with catgut on short intestinal needles. It is important that the ligation be done in the depth of the wound without causing traction on the meso-appendix. It should be remembered that next to the appendix the meso-appendix is the greatest source of spreading infection. Septic thrombi are easily dislodged, and these give rise to pyelphlebitis, and multiple abscesses of the liver, which are usually fatal.

No effort should be made to cover up the stump in the cases under discussion. It should be tied off and left, or in the presence of serious

Physical examination revealed a well nourished white, middle-aged man, with neglected teeth and mucous membranes of a fair color. The lungs were normal. The heart was not enlarged, a soft systolic bruit was present at the apex. The blood pressure was 135 systolic and 80 diastolic. The abdomen was normal, the liver and spleen not enlarged. The lumbar spine was held rigidly with muscle spasm over the seventh thoracic vertebra, more prominent on the right. In the anterior axillary line over the seventh right rib was a fusiform swelling which, on exploratory incision, showed a pathologic fracture of the rib.

Examination of the blood showed red cells, 2,092,000, hemoglobin, 55 per cent, white cells, 5,500, the differential count showed 10 per cent large mononuclears and transitional cells. The Wassermann test of the blood was negative. The urine gave a two plus reaction to the albumin test with white blood cells and casts. The excretion of phthalein was 40 per cent for two hours. The presence of Bence-Jones proteins was doubtful on the basis of the limited tests performed.

Roentgen-ray examinations showed multiple involvement by destructive tumors of the bone of the thorax with compression of the seventh and eighth dorsal vertebrae and fracture of the seventh right rib. The skull was rarefied and the frontal sinuses were large.

The patient had a fever of from 100 to 103 F and toward the end became confused, agitated and had moderate delirium, finally he became comatose, dying on June 21, 1922.

At necropsy, the anatomic diagnosis was myeloblastic myeloma involving the seventh and eighth dorsal vertebrae, the eighth rib on the right with pathologic fracture, arteriosclerosis, chronic diffuse nephritis with calcification and lipoma of the renal cortex, and terminal bronchopneumonia.

Microscopic examination showed different types of cells dominating in different portions of the tumor, around vessels and bone spicules a homogeneous type of myelocytic cell was seen, while in the fatty matrix of the marrow the plasma cell type was interspersed, with eosinophils predominating. At points in the tumor there was intermingling of all types of cells.

CASE 8—Mrs. S., a white woman, aged 72, was referred to Dr. Bloodgood on May 21, 1922, with a complaint of rheumatic pains in the arm of two years' duration. While carrying a bundle, something "gave way" in the left forearm. Localized pain or swelling at the site of the pathologic fracture had not been noted previous to the accident.

On physical examination, a yielding tumor was found about 25 cm in diameter and 22 cm below the left elbow. Small palpable nodules and depressions were present in all the long bones, and a large depression was palpated in the occiput of the skull. The remainder of the physical examination did not disclose anything of special interest.

The examination of the blood showed a hemoglobin content of 74 per cent with 4,668,000 red cells, 8,800 white cells, and a differential count of 53 per cent polymorphonuclear neutrophils and 39 per cent lymphocytes, the remaining 6 per cent was comprised of large mononuclears and transitionals. The Wassermann test of the blood was negative. The urine showed a 1 plus albumin and a positive test for Bence-Jones proteins.

Roentgen-ray examination showed fifty-six punched-out circular areas of various sizes scattered through the spine, sacrum, skull and the long pipe bones.

The left arm was amputated, but death followed shortly afterward.

Pathologic examination of the amputated arm showed a large soft, purple tumor, involving the left ulna with complete bone destruction in the area of the tumor.

cation with the main abscess cavity. An incision into the abscess in such cases will drain the infection directly from the original focus as well. But the appendix is somewhat of a rover, and the farther from its normal habitat it has taken up its residence, the more apt it seems to be to get itself into trouble and to cause trouble. One finds, therefore, the most serious complications when the gangrenous appendix is located in the middle of the abdomen or behind the cecum.

In our experience, the former situation is the most deadly. At the beginning of the attack, adhesions begin to form between the mesenteries and loops of the small intestine, and obstruction of the bowel complicates the infection from the start. The abscess or abscesses form along the mesentery, and it may be humanly impossible to open and establish efficient drainage to every infected nook and side chamber before the final review on the autopsy table. We have encountered serious retrocecal infections less often. There have been but three cases of subphrenic abscess in our series. This danger has always been kept in mind, and special efforts have been given to the placing of drainage after every retroperitoneal appendectomy.

The abnormally located appendix seems to be most apt to produce multiple pus pockets of irregular outlines, but usually communicating with one another. In such cases, it does not suffice merely to drain one pocket and stop. The appendix may be some distance away from the abscess first found near the abdominal wall. The partial release from intra-abdominal pressure may close the communicating sinus from the appendix to the opened abscess cavity, and the fire continues to smolder in its concealed furnace. We have therefore found it advisable to adopt the following working rule: The more concealed a suppurating appendix is and the harder it is to find, the more important it is for the patient's welfare and for the surgeon's mortality records that this appendix be found, removed, and the place whence it came, drained.

While we believe in the principle that it is to the patient's best interest to have the acutely inflamed appendix removed as the first step in treatment, irrespective of the extent of the peritoneal infection, it is not recommended that every physician who assumes the responsibility of operating for acute appendicitis should consider it his duty to remove the appendix in all cases of abscess—far from it. The "occasional operator" may glory in his ability to find and remove every "cold" appendix for which he makes a search, but he should refrain from spending time and energy in trying to locate a gangrenous appendix securely hidden in some concealed niche of a densely infiltrated and suppurating wall of adhesions. It would prove disastrous to many of his patients, if he were to do so before he has gained a tactile familiarity with the various fixtures in the abdomen and before his finger has learned to enucleate an

The gross specimen of the amputated leg showed a large soft, but not hemorrhagic, tumor in the lower third of the femur erupting through the bone and involving soft tissues

Microscopic examination showed large pale cells with typical nuclei, ranging up to giant multinuclear cells. The chromatin, however, was much more sparse, yet murally arranged. Mitotic figures were seen.

CASE 11<sup>8</sup>—C, a man, white, aged 37, with a previously negative history, had an illness which began fourteen months after an injury to the right shoulder. At first there was pain and tenderness over the right clavicle followed by a symmetrical tumor three weeks later. The tumor recurred in the first rib two months after resection of the clavicle. The patient became progressively worse, and death occurred four months after recurrence of the condition. Diplopia developed shortly before death.

Bence-Jones bodies were constantly present in the urine, there was no evidence of nephritis. The tumor was diagnosed myelocytic myeloma on microscopic examination by Welch, Bloodgood, McCallum and Crile.

CASE 12—J S, a man, white, aged 62, was admitted to the Johns Hopkins Hospital on Nov 16, 1922, with a complaint of pain in the back. The family history was negative. He had had nocturia in the past, and recently, epistaxis with pathologic fracture of the wrist. The present illness began two years before admission to the hospital, with pain in the shoulders and back radiating to the ribs. He was treated at the Johns Hopkins Hospital Dispensary for hypertrophic arthritis. One year previous to admission, a nodule appeared on the sternum in the jugular notch. On physical examination, evident loss of weight and pallor of the mucous membranes were found. There were dorsal kyphosis and rigidity of the whole spine with pain on flexion. There was a palpable tumor in the episternal notch to the right side and top of the sternum. The heart and lungs were normal. The blood pressure was 158 systolic and 108 diastolic. The liver and spleen were not palpable.

The blood showed a hemoglobin content of 35 per cent, red blood cells, 2,000,000, white blood cells, 6,800, a differential count showed 48 per cent polymorphonuclears, 40 per cent lymphocytes, 11 per cent mononuclears and transitionals. The Wassermann test was negative. The urine showed Bence-Jones proteins—21.7 Gm in twenty-four hour specimen of 1,800 cc. The excretion of phthalein for two hours was 30 per cent. Urine from the case preserved in the clinical laboratory shows the Bence-Jones reaction still present eight years later.

The roentgenogram showed slight but multiple involvement of the vertebral columns. The patient did not remain in the hospital. Biopsy was not obtained.

CASE 13—W T S, a man, white, aged 59, was admitted to the Johns Hopkins Hospital with the complaint of kidney trouble and general weakness. The family history was noncontributory. He had had malaria ten months before admission. There was a history of epistaxis and hemorrhoids.

The present illness began fifteen months before entry, with cachexia, irritability and urinary difficulty. There was increase in nocturia and difficulty in controlling the flow, and pain in the precordium.

On physical examination, there was loss of weight and pallor of the mucous membranes. The clavicles were prominent and right dorsal scoliosis existed.

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<sup>8</sup> This case, no 11, on file in the surgical pathological laboratory of the Johns Hopkins Hospital has been mentioned by Bloodgood. *Progressive Medicine*, 1906, vol 4, p 229. This summary only is included here for completeness.

to aggravate and complicate acute appendicitis. The great majority of all the severe cases we have seen, including practically all the patients who had early and hopeless peritonitis, had been given a cathartic soon after the onset of the disease. One may forgive an overzealous mother who tries to do the best she can, but it is most distressing to see medical men of modern education still addicted to the medieval and pernicious habit of prescribing cathartics when they are as plainly contraindicated as they are in acute appendicitis.

#### POSTOPERATIVE RESULTS

We believe our results give several definite hints as to the advisability of removing the appendix at the primary operation. Appendectomy was performed in 262 of the 289 cases of abscess, leaving twenty-seven in which drainage was established without removing the appendix. In several of the cases in which appendectomy was not performed, drainage was obtained through the vagina, in others there were complicating diseases which were assumed to contraindicate all operative procedures beyond a simple incision and draining of the abscess. But in the majority of these cases, the appendix was left behind, because the surgeon was unable to locate it without too extensive manipulations and expenditure of time. The postoperative complications were proportionately greater in the twenty-seven than in the rest of the group. A much longer period of hospitalization was necessitated by the prolonged suppurations which usually followed a nonremoval of the appendix. Most of the secondary abscesses and additional operations for their relief and nearly one half of the postoperative enterostomies for obstruction of the bowel were among these same twenty-seven. The appendix had not been removed in three of the seven cases of abscess in which death occurred.

The two patients in the group of cases of peritonitis from whom the appendix was not removed died from toxemia soon after the drainage operation. Their desperate condition could not have been improved by any form of technic. We feel convinced, however, from a comparison with earlier experiences in progressive peritonitis that a ruptured appendix remaining in the abdomen after a simple drainage operation acts as a potent feeder for further extension of infection and complications. When the cause of the infection is removed, the patient has a better chance to overcome the damage already wrought on the peritoneum.

The following conditions were outstanding and instructive among the patients who died.

A boy, aged 10, who died from multiple abscesses of the liver after the removal of a rather mildly inflamed appendix without abscess, proved

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*Grouping of 1,000 Cases of Acute Appendicitis According to Extent of  
Peritoneal Infection*

\* Group I includes cases of infection confined to the appendix, group II, abscess, and cases with peritoneal infection restricted to immediate neighborhood of the appendix (i. e., early stage of progressive peritonitis), and group III, cases of diffuse and progressive peritonitis

	Group I	Group II	Group III
Total number of cases	551	289	160
Appendectomy made in	551	262	158
Appendectomy not made in	0	27	2
Died	2	7	18
Age of Patients			
Youngest	4 years	1½ years	3 years
Oldest	60 years	67 years	62 years
Average age	21 years	29 years	20 years
Time of Operation after Onset			
Shortest	½ day	1 day	1 day
Longest	11 days	35 days	21 days
Average	2½ days	4½ days	3½ days
Duration of Drainage			
Shortest	1 day	2 days	5 days
Longest	20 days	120 days	60 days
Average (of those drained)	2 days	12 days	15 days

Major Postoperative Complications

Group I	Group II	Group III
Pneumonia 5	Intestinal obstruction (secondary) 22	Intestinal obstruction (secondary) 16
Cholecystitis 3	Enteritis 5	Enteritis 6
Phlebitis 2	Secondary abscess 5	Pneumonia 3
Pylephlebitis 1	Peritonitis 4	Abscess of abdominal wall 3
Pyosalpinx 1	Phlebitis 4	Postoperative hemorrhage 2
Ovarian cyst (large) 1	Hernia incarcerated 2	Subphrenic abscess 3
Abscess of the abdominal wall 1	Pneumonia 2	Phlebitis 2
	Pylephlebitis 1	Abortion 2
	Subphrenic abscess 1	Otitis media 2
		Parotiditis 1
		Abscess of the lung 1

Secondary Operations

Reopen wound for infection 3	Enterostomy (including 7 primary) 29	Enterostomy (including 21 primary) 40
Cholecystectomy 2	Secondary abscess 6	Closure fistula 5
	Closure fistula 5	For infection of abdominal wall 3
	Appendectomy 5	Thoracotomy 2
		For postoperative hemorrhage 1

Mortality

Pneumonia 1	Intestinal obstruction 2	Toxemia (within 36 hours after operation) 6
Multiple abscesses of the liver 1	Hernia and peritonitis 1	Intestinal obstruction 6
— 1	Peritonitis 1	Pneumonia, lobar 1
— —	Subphrenic abscess 1	Pneumonia, aspiration 1
Total 2	Multiple abscesses of the liver 1	Gangrene of cecum 1
(0.36%)	— 7	Intestinal extrusion 1
	Total (2.42%)	Embolism (2 months after recovery from appendectomy) 1
		Sulfide 1
		Total (minus last two) 16
		(10%)

Average mortality in 1,000 cases, 2.5%

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In general, statistics covering cases from group 1 show from 80 to 90 per cent of five year "cures," and the English statistics show 90 per cent of ten year cures in the Leeds series. My group shows 83 per cent of five year cures. Statistically, my group 1 is possibly skewed by the inclusion of cases 5 and 40. In case 5, the patient died in a manner similar to that observed in class 2, group A. My records fail to mention axillary metastases, but the rapid fatal recurrence would seem to indicate that there were metastases that were not found or recorded. In case 40, operation was performed under the diagnosis of Paget's disease. Because of advanced mitral stenosis, a complete radical amputation was not attempted. The local recurrence was a typical scirrhous cancer.

As a rule these patients in class 1 come to operation at a relatively early period following the discovery of the tumor, but the variation in

TABLE 1—*Data of Cases in Class 1*

Case Number	Preoperative Time, Months	Postoperative Time, Months	Present Condition
52	2	16	Satisfactory
46	$\frac{1}{4}$	28	Satisfactory
48	1	24	Satisfactory
39	12	60	Satisfactory
30	$\frac{3}{4}$	84	Satisfactory
26	$1\frac{1}{2}$	108	Satisfactory
40	6	60	Recurrence
24	1	84	Died of cancer
19	?	182	Satisfactory
18	?	132	Satisfactory
13	$\frac{1}{2}$	162	Satisfactory
7	?	180	Died of cancer
10	?	180	Satisfactory
5	4	19	Died of cancer
11\	3	168	Satisfactory

time of from one week to twelve months is so great as to make the average, three months, of little statistical significance. The English series shows a mean duration previous to operation of more than six months.

It is not necessary to comment further on results in class 1. If all cancers of the breast could be operated on before glandular involvement, this disease would be largely conquered.

My series comprises thirty-one cases in class 2. The results in this class present a sharp contrast to the generally satisfactory results shown in cases in class 1. Of twenty-one patients operated on five or more years ago, only six were alive at the end of five years and three of the six died later of cancer. My results in cases in class 2 have been essentially similar to those reported by other surgeons the world over.

In the past, all physicians were inclined to credit such results as are shown in cases 14, 16 and 35 to the thoroughness of the operative

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Group A is of particular interest so far as it illustrates how in operations for cancer the term "early" cannot be defined in terms of time. This group is composed of sixteen cases in all of which operation was performed within four months of the discovery of the tumor. The average interval is 2.3 months or approximately nine weeks as compared with about thirteen weeks in the cases in class 1. The distinguishing feature of group A is that each case did show metastases of the axillary glands at the time of operation. Irrespective of any potentially malignant characteristics lurking in the individual tumors comprising class 1, not one of them had up to the time of operation demonstrated the capacity of producing early glandular metastases. In group A, on the other hand, each individual tumor demonstrated malignancy of a degree capable of producing axillary metastases in less than four months and in most of the cases in less than two months following the discovery of the tumor.

TABLE 3—*Data of Cases in Class 3*

Case Number	Preoperative Time, Months	Postoperative Time, Months	Present Condition
38	60	36	Died of cancer
36	12	6	Died of cancer
31	156	36	Died of cancer
25	4	30	Died of cancer
17	30	6	Died of cancer
9	42	60	Died of cancer
6	24	22	Died of cancer
1	12	2	Died of cancer

The literature on cancer is filled with statements to the effect that early operation is the one most important factor if a cure is to be obtained. To the laity and probably to most physicians, this term signifies some relationship measurable in intervals of time. Usually, it is taken to mean that a short interval has elapsed between the first discovery of a lump in the breast and the time of operation.

That this time interval is not per se a dominant factor in regard to postoperative prognosis is readily shown by comparing the results obtained in cases in class 1 with those shown for group A of class 2.

The cases in class 1 were "early" cases, the term being used in a purely anatomic and pathologic sense, but they were not necessarily particularly early in the sense of time interval. The cases in class 2, group A were, however, all early cases in a sense of time interval, in all the cases, operations were performed within four months of the discovery of the tumor, the average time interval was only about nine weeks, and yet this group is the worst of all groups as regards prognosis. These cases in group A all showed axillary metastases at an early stage in the growth of the tumor. That this early metastasis actually

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or tenderness could not be elicited and there was no increase in temperature or pulse rate. The pain gradually subsided, only to recur again in a few days. These attacks of ill defined and poorly localized pain persisted for about three weeks, when the patient began to expectorate large quantities of pus, which relieved him from pain. At the same time, his temperature and pulse rate increased. Finally, the day before his death, the patient was rushed from the country to the hospital in an effort to save his life. An operation was not attempted because of the poor condition of the patient. He died a few hours after admission.

The pertinent conditions found at autopsy were as follows. The abdomen was markedly distended and tympanitic. Free fluid or pus were not found in the peritoneal cavity. Both large and small intestines were greatly distended. On separating the cecum from the muscles of the flank an abscess was opened, it contained but a small quantity of pus (about 5 cc.) The abscess cavity was lined with a shaggy, dirty, greenish-black, scant exudate. Adherent to the posterior part of the cecum, in the wall of the abscess, lay the appendix, which was in a necrotic condition. The abscess cavity continued upward, between the posterior part of the ascending colon and the posterior abdominal wall, as a sinus tract about 1 cm. in width and of a greenish-black, moist appearance, containing necrotic material with a stale fecal odor. The portion of the colon that formed the anterior wall of this tract was black and necrotic and tore on the slightest manipulation. The tract continued upward, lateral to the perirenal tissue and behind the right lobe of the liver. It communicated with the right pleural cavity through a perforation in the dome of the diaphragm in its extraperitoneal portion, between the coronary ligaments of the liver. The tract throughout its entire length presented the same blackish appearance. There was no collection of pus immediately below the diaphragm.

The right pleural cavity showed a hemorrhagic, purulent exudate over the base of the lung, which was adherent to the diaphragm. The lung was nodular and irregular, due to the areas of consolidation, which were dark red, irregular and slightly raised above the surface. On section, they showed a softened, yellowish center, surrounded by a firm, reddish zone of varying width. Many such nodules were scattered throughout the lobes of both lungs.

CASE 3—Z H, aged 23, one week before admission, had had a criminal abortion performed by insertion of a rubber catheter. This was passed the next day and was followed, two days later, by a fetus and placenta. On the day of admission to the hospital, the patient developed severe epigastric and lower abdominal pain, unaccompanied by vaginal bleeding or discharge. On admission, the temperature was 102 F, the pulse rate, 120 and respirations, 25. The abdomen was rigid and tender throughout. There was a suggestion of a friction rub at the left base. The blood count revealed 27,600 white blood cells and 90 per cent polymorphonuclears. Two days after admission, nausea and vomiting developed, which became fecal two days later. The temperature was septic. The patient did not complain of difficulty in breathing or of pain in the chest. Death occurred on the seventh day.

The salient points at autopsy were as follows. Gas escaped as soon as the peritoneum was opened. The enormously distended intestines were matted together and contained pockets of thick, yellowish, foul-smelling pus between the coils. A perforation could not be found. There was a thick mass of somewhat inspissated pus in the floor of the pelvic cavity. A perforation could not be detected in the vaginal vault either from within the vagina or from the pelvic cavity, nor in the uterus, which was somewhat enlarged, softened and covered

TABLE 1—Cause of Amputation

Percentage	Cause	Total	Primary Cases	Thigh	Lower Leg	Upper Arm	Fore arm
26.9	Trauma	118	104	26	37	23	27
10.0	Sepsis	42	35	21	19	0	2
9.5	Endarteritis thrombo angietis Reynard's	40	30	19	18	0	3
9.5	Painful amputation stump	40	21	13	27	0	0
8.8	Tuberculosis	37	37	9	19	3	6
8.5	Diabetes (gangrene)	36	28	21	15	0	0
8.5	Arteriosclerosis (gangrene)	36	35	29	7	0	0
7.1	Sarcoma	30	28	21	3	6	0
2.6	Carcinoma	11	11	3	4	1	3
2.3	Thrombosis and embolism	10	9	7	2	1	0
1.9	Gas bacillus infection	8	8	4	1	1	2
0.9	Ununited fracture	4	4	3	1	0	0
0.7	Ruptured brachial plexus	3	3	0	0	3	0
0.7	Spina bifida	3	1	0	3	0	0
0.4	Charcot joint	2	1	1	1	0	0
0.2	Foot deformity (contracture)	1	1	0	1	0	0
0.2	Trophic ulcer	1	1	0	1	0	0
0.2	Tetanus	1	1	1	0	0	0
0.2	Pressure of pelvic tumor	1	1	1	0	0	0
0.2	Gangrene after ligation for popliteal aneurysm	1	1	0	1	0	0
		420	360	170	160	38	43

TABLE 2—Postoperative Mortality in 360 Primary Amputations

Cause of Death	Number	Percentage
Shock, traumatic or postoperative *	9	2.1
Septicemia	10	2.3
Bronchopneumonia	8	1.9
Diabetes	5	1.3
Gas bacillus infection	3	0.8
Cause undetermined	3	0.8
Pulmonary embolism	2	0.5
Cardiac decompensation	2	0.5
Tetanus	1	0.2
Pulmonary tuberculosis	1	0.2
Uremia	1	0.2
Polycythemia (multiple infarction)	1	0.2
Pneumothorax	1	0.2
Cerebral thrombosis	1	0.2
Lobar pneumonia	1	0.2
	49	11.6

\* Ten patients with complete traumatic amputation died soon after admission without any operation being performed, but are not included in this tabulation

TABLE 3—Four Hundred and Twenty Amputations Postoperative Complications

Total	Percent- age	Complications	Thigh	Lower Leg	Upper Arm	Forearm
77	20.8	Wound infection (pyogenic)	35	31	4	4
17	4.1	Extensive slough of flap	8	8	0	1
14	3.3	Postoperative shock	8	3	2	1
12	2.8	Septicemia	8	2	0	2
11	2.6	Gas bacillus infection (B. Aerogenes capsulatus)	5	4	0	2
10	2.4	Bronchopneumonia	7	2	0	1
8	1.9	Extending gangrene	2	6	0	0
3	0.7	Diabetic coma	1	1	0	1
2	0.4	Pulmonary embolism	2	0	0	0
2	0.4	Postoperative hemorrhage	2	0	0	0
2	0.4	Osteomyelitis	0	1	1	0
1	0.2	Cerebral thrombosis	1	0	0	0
1	0.2	Tetanus	0	1	0	0
1	0.2	Auricular fibrillation	1	0	0	0
1	0.2	Cardiac decompensation	1	0	0	0
1	0.2	Pneumothorax	0	1	0	0
1	0.2	Diabetic acidosis	1	0	0	0
1	0.2	Phlebitis	0	0	0	1
1	0.2	Uremia	1	0	0	0
1	0.2	Delirium	1	0	0	0
167	41.6		84	63	7	13

Clinically, subdiaphragmatic abscesses have been divided into gaseous and nongaseous, because of the different clinical pictures presented. While this division may be of help from a clinical standpoint, its usefulness from a pathologic point of view is questionable, for the same etiologic factor may in one instance produce a gaseous and in another a nongaseous abscess. For example, a perforated gastric ulcer may produce a gaseous abscess resulting from swallowed air, while in another patient gas may not be present, or appendical abscesses, which are generally simple and nongaseous, may contain air as a result of bacterial activity.

In case 1 there was a typical perinephritic abscess. It differed from the usual abscess in this location, because it did not perforate the diaphragm in the right anterior intraperitoneal space of Barnard, below the right anterior coronary ligament of the liver. It formed, however, a second subdiaphragmatic abscess between the layers of the coronary ligament in the right extraperitoneal space, a space usually occupied by a subphrenic abscess resulting from intrahepatic suppuration.

Case 2 illustrates an extensive retroperitoneal inflammatory process resulting from a retrocecal appendix and perforating the diaphragm in its extraperitoneal portion. This case is unusual in that there were no signs of inflammation in the true peritoneal cavity, apart from a paralytic ileus, although a rather extensive inflammatory and necrotic process had been present within the abdomen for a month.

Case 3 is the first instance of its kind that has come to my attention in which the diaphragm was perforated during the course of an acute generalized suppurative peritonitis. In long-continued cases of intraperitoneal suppuration, it is not unusual to have secondary foci set up in the pleural cavity by extension through the lymphatics or blood stream, but appreciable losses of diaphragmatic substance with large or small perforations occurring during an acute generalized peritonitis are most uncommon. This case could not rightly be termed a case of subphrenic abscess, for the condition was extensive throughout the abdomen. Perforation of the diaphragm had occurred in the left anterior intraperitoneal space of Barnard in the dome of the left side of the diaphragm.

In a search through the medical literature, I have been unable to find a similar case reported. It is a condition of such uncommon occurrence that it is not mentioned as a possible complication of peritonitis in standard works of medicine and surgery (Osler's System of Medicine, Keene's System of Medicine, and others). The evident rarity of its occurrence accounts for these brief case reports.



being inserted The open type of amputation has been employed also in many of the traumatic amputations Here is has been the policy to divide the limb at the level of the wound or of the fracture if one existed, to excise all soiled and devitalized tissue, saving as much healthy skin as possible to aid in the latter closure at a later period and to leave the wound open

In all cases of open amputations, extension has been applied to the skin soon after the operation to prevent retraction of the skin and soft parts Most of these wounds have been left to heal by granulation

TABLE 6—*Period of Hospitalization*

	Cases	Longest Stay, Days	Shortest Stay, Days	Average Stay, Days
Amputations of the thigh	174	189	10	41
Amputations of the lower leg	161	193	9	36
Amputations of the upper arm	37	71	7	26
Amputations of the forearm	42	66	9	23

TABLE 7—*Frequency of Open Amputation, Closed Amputation, and Use of Drainage*

	Percentage	Total	Thigh	Lower Leg	Upper Arm	Forearm
Open amputations	12.4	36	16	13	3	5
Closed amputations	87.6	254	103	101	25	25
a With drainage	72	183	67	70	23	23
b Without drainage	28	71	36	31	2	2

TABLE 8—*Wound Healing in Thirty-Six Open Amputations*

	Percentage	Total	Thigh	Lower Leg	Upper Arm	Forearm
Healed by granulation	58.3	21	9	5	3	4
Closed by secondary suture	11.1	4	2	2	0	0
Required skin grafting	22	8	4	3	0	1
Not healed at discharge	8.3	3	1	2	0	0

(table 8) Some have been treated by the Carrel-Dakin method of wound sterilization, and of these a few have been closed successfully by secondary suture In some of the cases, healing has been hastened by grafting of skin

In cases of open amputation, the patients have uniformly made favorable progress, and acute septic complications have been rare On the other hand, secondary plastic operations or reamputations have been required later in most of these cases to secure suitable stumps for limb fitting

In primarily clean cases, the amputation has been of the closed type Drains have been inserted in 183 of 254 such cases, or 72 per cent, frank

appendicitis This signifies that there has been an increase of 30 per cent in the mortality of this disease within the past decade and it means that as many people die from appendicitis each year as from ectopic pregnancy, pyosalpinx, gallstones, and pancreatic, splenic and thyroid gland disease combined These figures, even if only approximately correct, suggest that no member of the surgical profession has a right to rest on the laurels of his record in cases of appendicitis, no matter what they be, but rather that he should be urged to a more intensive study of the whole problem of acute appendicitis

Many writers seem to gage the severity and prognosis of a given case of appendicitis entirely by the length of time between the onset of the attack and the operation In the majority of cases this relationship between cause and effect is undoubtedly present, yet there are many cases in which the appendix will be in a state of acute inflammation for several days before it becomes surrounded by infectious exudate There may be a milky exudate of considerable quantity, but a culture of it will often prove it to be sterile In many cases of this type healing occurs promptly after appendectomy and without marked inflammatory reaction It does not seem fair to include such cases among those of late appendicitis or peritonitis They belong essentially to the class of uncomplicated acute appendicitis even if three or more days have elapsed since the first symptom appeared

Again it happens not infrequently that gangrene occurs early and that the cultured exudate is found to be infectious in much less time than the forty-eight hours usually mentioned as an arbitrary time limit between a clean and an infected peritoneum Free and virulent pus has been encountered on many occasions in less than twenty-four hours after the acute symptoms began

The true extent of the pathologic process present in any given case cannot be definitely known until the incision has been made With the pathologic process before his eye, the surgeon should judge by what he sees and feels in each case rather than by what he remembers about the time of onset, and he must base his method of treatment on the judgment he forms concerning the degree and extent of the infection

Having adopted a classification on this principle, we have divided the 1,000 cases into three groups

Group I, acute appendicitis, group II, acute appendicitis with abscess, and group III, appendicitis with progressive peritonitis

The first group includes all cases in which the surgeon was reasonably sure that there was as yet no infection of the surrounding peritoneum In many cases which were placed in this class the appendix showed gangrenous areas, was covered with fibrin or was

## END-RESULTS

A follow-up study has been made of the 360 cases of primary amputation included in this group. End-results have been ascertained in 253 cases, or 70 per cent, of the total. As these amputations were performed from 1916 to 1925, inclusive, it will be seen that none of the results was obtained less than one year postoperatively, and that the majority are of much longer duration (table 10).

The causes of death of those who have died since leaving the hospital are shown in table 11.

Data have been sought with regard to three main points, as follows:

- 1 Functional results in relation to amputations at different levels
- 2 Surgical results as indicated by the number of reamputations and secondary operations
- 3 Disease results with regard to the cure of the condition which necessitated amputation

TABLE 10—*End-Result Tabulation (360 Primary Amputations)*

	Number Percentage		
Postoperative deaths in hospital	49	or	13.6
Known deaths since leaving hospital	56	or	15.5
Alive and end results known	148	or	41
Total number of end results	253	or	70.2
Not located	107	or	29.8
	360		100
Reamputation required in	52	or	14.4

The cases have been analyzed from these three points of view, and the results will be presented under these three headings.

## FUNCTIONAL RESULTS

The end-results with reference to present function have been grouped according to the level of amputation.

*Disarticulation of the Hip*—There were nine cases of disarticulation of the hip with a postoperative mortality of two or 22 per cent. Notes on the functional end-result have been obtained in three of the remaining seven cases; the other patients have either died or have not been located.

Two of the patients found were adults and the other was a boy, aged 11. In the former, the cause of amputation in one case was old tuberculous disease of the hip joint with secondary pyogenic infection, in the other, a high traumatic amputation leaving a stump which was covered with a broad, thin, sensitive scar and was too short to actuate an artificial leg. Secondary disarticulation of the hip was performed to improve the functional result, and it is interesting to note that this patient was the only one of the three to make use of an artificial limb. The third case was that

patients to the operating room practically without preliminary treatment, with a conviction that the patient's best chance for recovery lay in the quickest possible removal of the appendix and the establishment of efficient drainage from the infected peritoneum. It should be stated in this connection that acute appendicitis has been considered an emergency of first importance over which neither the pressure of office hours nor the surgeon's rest at night has been allowed to take precedence. As a matter of fact, the majority of these operations were made in the hours between sunset and sunrise.

Nitrous oxide and oxygen gas anesthesia has been used in most of our work. A small amount of ether has been added occasionally. In all serious surgical risks, an infiltration of 0.5 per cent solution of procaine hydrochloride has preceded the abdominal incision. Practically all secondary enterostomies have been made with local anesthesia.

We do not use lateral, longitudinal incisions in the abdominal wall for any purpose, and can see no valid reason for the use of the right rectus incision in surgical intervention in appendicitis. We practice the so-called split muscle incision, and in the few instances in which the mere splitting gives too little room, the incision is enlarged by cutting across the linea semilunaris. The separation of the aponeurotic fibers may then be continued and, if need be, a section of the rectus may be severed. A second split muscle incision near the left groin is made when needed for additional drainage or for immediate enterostomy.

When the surgeon unexpectedly encounters a posterior appendix, he may sometimes find his split muscle incision too low for the necessary ligations of high blood vessels. The incision through the skin and external oblique is then extended upward, and the deeper muscles and the peritoneum are split at a higher level. This double opening is much more conservative of anatomic structure than the practice of cutting across muscle and nerve fibers.

We know from experience that sufficient room for the required surgical procedure under discussion is practicable through split muscle incisions. We also know that in virulent infections the abdominal wall suffers permanent damage in proportion to the operative damage inflicted at the time of operation.

We believe that the low percentage of postoperative hernia in our series is another distinct benefit derived from the conservative incisions. "Follow-up" inquiries have disclosed but fifteen incisional hernias up to date, or 1.5 per cent. Only eleven of these caused sufficient trouble to bring the patient back for herniotomy. It is interesting that the only patient on whom a modified right rectus incision was made returned with a hernia.

ness, diabetes, mental deficiency or senility In three cases it was because of lack of funds

The prosthetic history was noted in twenty-eight cases This is shown in table 13 The best results were obtained in those cases in which a temporary appliance had been fitted This was of the peg leg type, usually constructed from the lower half of a crutch with plaster of paris socket Such an appliance had been used in ten of the twenty-eight cases, being fitted on the average 16 months after the operation Because of the simplicity and light weight of such an appliance, the patient is able to use it even when the stump is still sensitive It

TABLE 12—*Amputations of the Thigh Functional Result in Relation to Length of the Stump*

Length of Stump	Good	Fair	Poor	Total
Upper third	1	1	3	5
Middle third	5	0	3	8
Lower third	2	3	0	5
	<u>8</u>	<u>4</u>	<u>6</u>	<u>18</u>

TABLE 13—*Prosthetic Results After Amputation of the Thigh*

Using artificial leg	24
No difficulties experienced	21
Fit of limb unsatisfactory	3
Not using artificial leg	4
Patient too weak	1
Limb too heavy	3
Total	<u>28</u>
Fitted with provisional appliance	10
Average time from operation to receiving temporary appliance	16 months
Average time from operation to receiving permanent leg	
When provisional leg had not been used (19 cases)	13.3 months
When provisional leg had been used (9 cases)	5.5 months
Average time saved	<u>7.8 months</u>

improves the circulation in the stump, hastens shrinkage, strengthens the muscles and restores the normal mobility of the joints far better than any other agents

The economic side always looms large in the cases of amputation of the thigh Notes as to occupation were made on thirty-two patients (table 14) seventeen of whom are working and are wholly or largely independent, while fifteen have no occupation and are entirely dependent Nine of these are men over 64 years of age with various forms of senile debility Most of the others are suffering from some form of disease Of the seventeen who are employed, six are working at the same occupations as prior to amputation and have not been affected economically the rest have had to change their occupations and to find tasks fitted to their disability

distention, a small rubber tube may be passed through it into the cecum. Fear need not be entertained about the possibility of a resulting fistula. Such fistulas soon heal and are serviceable while they last.

Cigaret drains of soft dental rubber are much better, in our opinion, than rubber tubes. A gauze tampon, surrounded by rubber, may occasionally be required over a deep bleeding area. The amount of drainage material used should be large when the peritoneal infection is extensive. Ten or a dozen long and soft rubber cigarettes have frequently been inserted. Two or three rubber gloves, sometimes packed with gauze wicks, have been placed in the pelvis to hold the intestine away and to aid the exudate in finding an easier path to the outside. This is in line with Lennander's teaching of many years ago. He advised that in acute peritonitis the most important part of the treatment was to "lay the infected peritoneum extraperitoneal." The immediate storm is usually over in two or three days, and then the quantity of drainage material can be reduced rapidly by withdrawing one or more cigarettes at each dressing. When a large quantity of rubber is used, there is not likely to be as much difficulty in its removal as when one or two small cigarettes become entangled deep in the abdomen.

The incision should be placed low enough so that the drainage material rests against the parietal peritoneum externally and in the pelvis. This is for the purpose of minimizing the extent and amount of intra-abdominal postoperative adhesions. The suppurating tract, gradually decreasing in diameter, as the cigarettes are withdrawn, will be composed of visceral adhesions on its mesial side only. We have operated on a number of patients for obstruction of the bowel, both chronic and acute, because at some previous operation a discharging sinus and later fibrous adhesions had been allocated entirely within the abdomen with free and open peritoneal cavity all around.

In order to shorten the intra-abdominal length of the discharging sinus, we have on many occasions and with much satisfaction placed the edges of the peritoneum as deeply as possible along the rubber drains. This is easily done by packing loosely an iodoform strip or a rubber cigaret between the peritoneal margin and the transversalis muscle. In children and in adults with shallow ileocecal fossae, it is sometimes possible to fasten the mesial side of the peritoneal wound to the posterior peritoneum over the psoas muscle with a catgut stitch. This method is especially useful when the abscess is located within the pelvis. The peritoneal flap pushes intestinal loops away from the drainage material, and the exudate becomes extraperitoneal as soon as it reaches the brim of the pelvis.

In most cases in which there is a strictly localized abscess, the gangrenous or perforated part of the appendix is usually in free communi-

laborers The list of occupations is shown in table 15 Of the seven patients not working, all but two had definite disabilities

Twenty-four of thirty patients using artificial legs reported good function and no disabilities (table 16) Six patients were having trouble either with their stumps or with their legs Nine patients have had to have their appliances changed, some of them twice All this indicates that it is much more difficult to secure a satisfactory fitting leg in the case of amputations of the lower leg than in amputations of the thigh Stump troubles are common, especially in summer Chafing over the head of the fibula occurs frequently, and in many such cases the patient would

TABLE 15—*Occupations of Persons on Whom Amputations of the Lower Leg Had Been Performed*

Working—26 Patients, 79 per Cent		
Number	Present Occupation	Former Occupation
5	Housework	Same
2	Laborer	Same
3	Switchman	Brakeman
1	Clerk	Traveling salesman
1	Elevator man	Laborer
2	Janitor	Truck driver, same
1	Child's nurse	Laundress
1	Watchman	Same
1	Student	Same
2	Olgar maker	Same
1	Presser	Tailor
1	Shoe treer	Same
1	Holsting engineer	Same
1	Dressmaking	Same
1	Insurance broker	Traveling salesman
1	Store clerk	Farmer
1	Tailor	Same
Not Working—7 Patients, 21 per Cent		
	Reason for Not Working	Previous Occupation
3	Various forms of senile debility	Carpenter, salesman, railway inspector
2	Painful stump	Brakeman, metal junk dealer
2	No reason stated	Mill operator, labor foreman

be relieved by complete excision of the fibula On the other hand, when there is a good stump and a well fitting leg, the disability is almost negligible

The results obtained by the use of temporary appliances are not so striking in amputations made below the knee as in the case of amputations of the thigh This is because a more complicated appliance is used, one that has to be obtained outside the hospital There is often considerable delay in fitting it, the average time being 3.5 months as against 1.6 months in the amputations of the thigh There is no reason why these patients should not be fitted with temporary appliances as early as those on whom amputations of the thigh have been performed if this were done, we are confident that the same saving of time would result in the period between operation and the fitting of the permanent limb as in the former group of cases

adherent appendix without seeing it. Until sufficient experience has been reached, the best results will follow the least possible manipulating after the pus flows freely.

In the presence of intestinal distention and obstruction the surgeon must judge whether or not an immediate enterostomy should be performed. When the infection is widespread, the distention great and reverse peristalsis evident, enterostomy should be performed at once. If the peritoneal infection is only of a few hours' duration and the distention moderate, enterostomy may not be required. No rule can be formulated, as each case becomes a law unto itself. But it should be remembered that a properly made temporary opening into the intestine does not injure any of these patients, and that it is the only salvation for many. We have never regretted performing a primary enterostomy, we have often regretted its postponement.

It is best not to place the enterostomy tube, or tubes, in the operative wound. We have found it preferable to perform this supplementary operation in a second split muscle opening, near the left groin or flank, with a fold of the omentum or a loop of the pelvic colon as a protection to the intra-abdominal part of the sinus.

Enterostomy was performed at the time of primary operation in thirty-one cases in our series, it was made at a later seance in thirty-eight. In a number of patients it was necessary to reoperate, one or more times, thus producing three or even four artificial openings. With a few exceptions, the sinuses closed spontaneously.

The draining of an exudate from any cavity takes place most quickly and efficiently if the cavity is opened at the bottom. The advisability of opening an abscess at its lowest point was known in ancient times. This principle holds true also when it is desired to drain an infected peritoneum through an opening in the anterior abdominal wall. Our patients have made safer, quicker and more comfortable recoveries since we learned to place them in bed in such a posture that the open wound is at the lowest point of the abdominal cavity. An abundance of pillows is placed on the bed and the patient is made to lie on his abdomen with the thorax elevated and the knees drawn up. It is essential that this posture commence immediately after the operation—when possible even on the cart from the operating room—in order to turn gravity in the right direction and at the time when it is most effective. An additional benefit from the ventral posture comes from the fact that the stomach and duodenum have less difficulties with retention and regurgitation, and the patient will be tortured with the stomach tube less often.

In spite of much effort to instruct both the public and physicians about the danger of giving laxatives haphazardly in acute abdominal lesions, castor oil, magnesium sulphate, and their equivalents, continue



The functional results are good in four cases and fair in one. The latter is a case of hemiplegia, and although the former deformity of the foot has been eliminated, considerable disability remains due to spasticity. All are working, being employed as shown in table 17. It will be noted that three are doing the same heavy type of work as before amputation.

The prosthetic result is good when a proper type of appliance is fitted. The ankle is large and bulky, however, and the cosmetic result in the case of a woman would not be satisfactory. For this reason, the operation has been performed only on men.

*Double Amputations of the Lower Extremities*—Notes on the end-results have been obtained in ten cases of double amputations of the lower limbs, and are shown in tables 18 and 19. As would be expected, the disability resulting from double amputation of the thigh is total. In four such

TABLE 17—*Occupations Syme Amputation*

Number of Cases	Present Occupation	Previous Occupation
1	Longshoreman	Same
1	Farm laborer	Same
1	Pedler	Same
1	Switchman	Trainman
1	Messenger	Watchman

TABLE 18—*Results in Double Amputations of the Lower Extremities*

	Number of Cases	Using Appliances	Working	Not Working	Disability Percentage
Amputation of both thighs	4	1 occasionally	0	4	100
Amputation of thigh and lower leg	2	1	2	0	75
Amputation of both lower legs	4	3	2	2	50 to 75

cases the patients are wholly dependent and live a wheel chair life. One has been fitted with short peg legs, and with these and the aid of canes he is able to get about a little. Double amputations of the thigh and lower leg yield considerably better results. Two cases of this type were followed. One patient gets about fairly well, the other is not able to walk. A great deal depends on whether the patient is in good general health and possesses the necessary initiative and determination. In bilateral amputations of the lower part of the legs, good functional results are obtained, provided the stumps are sound and the general health and strength good. One of our four patients is working as a laborer, although doubtless the work is made as light as possible for him. Three are using appliances with satisfactory function. The fourth is in poor health and cannot use prostheses.

*Amputations of the Upper Extremity*—Notes on end-results were obtained in thirty-four cases of amputation of the upper extremity, of which nineteen were amputations of the forearm and fifteen amputations

the necessity of handling an edematous meso-appendix with the utmost care. The other death in the simple acute cases was that of a child with respiratory infection who developed pneumonia after the operation.

Two of the deaths listed under appendicitis with abscess were indirectly due to a complication with incarcerated hernia and mistaken diagnosis. A woman, aged 60, with a frequent temporary incarceration of a large umbilical hernia, entered the hospital several days after one of her attacks of midabdominal pain. The hernial mass, as well as the whole right side of the abdomen, was hard and tender. At operation, incarcerations of omentum and colon were replaced, and an inflamed appendix and an abscess were discovered. The abscess was drained, the appendix was not removed. General sepsis and death followed. The second hernial complication was found in a young man who gave a history of occasional attacks of pain and distention in a right inguinal hernia. Four days after the beginning of such an attack, he entered the hospital with a large bulging mass in the inguinal canal. It was opened and found to contain pus, masses of fibrin and an incarcerated omentum. Drainage was instituted through the hernial sac, and the abdomen was not explored. He died from peritonitis five days later and two days after a gangrenous appendix had been discovered as the cause of the infection. One patient with chills, both before and after the operation, died three weeks later from multiple abscesses of the liver.

In the group of cases of peritonitis, it should be noted that of the eighteen patients who died, two were men, 59 and 62 years of age, both of whom had complicating cardiorenal inefficiency. Preliminary gastric lavage is very difficult in children, and aspiration of fecal vomitus during the operation and consequent pulmonary consolidation was the determining factor in the death of a child. Three had delirium and hyperpyrexia (over 105 F) before operation. One showed gangrene of the entire cecum at the autopsy. One had a serious secondary suppuration of the parotid glands, and one suffered an extrusion of the bowel a few hours after operation. The majority of the patients with peritonitis who died did so within two or three days after operation with symptoms of a continuation of the toxemia and of insurmountable obstruction of the bowel.

One patient, a young man, committed suicide after he had entirely recovered from his operation and was ready to go home, and another man, aged 60, died suddenly—probably from embolism—following an intestinal resection two months after the original operation for peritonitis. Strictly speaking, neither of these died from appendicitis, and it is doubtful whether they should be included in the mortality list. With these two cases excluded, the number of deaths was twenty-five, or an average mortality of 2.5 per cent in the 1,000 cases of acute appendicitis.

erally because of debility due to old age, to disease such as diabetes, or cardiac weakness

In amputations of the lower leg no patients who were well enough to walk did not use prostheses

Scarcely any of those whose upper arm had been amputated used appliances, when these were used, it was only for cosmetic reasons

TABLE 20—*Occupations of Persons on Whom Amputations of Upper Extremity Have Been Performed (19 Cases)*

Region of Amputation	Number	Present Work	Previous Work	Remarks
Disarticulation of the shoulder	1	Labor foreman	Laborer	Earns more than formerly
	2	None	None	Feeble-minded
	3	Office work	Same	
Amputation of the upper arm	1	Clerk	Same	In state asylum
	2	Watchman	Laborer	
	3	Housework	Same	
	4	None	None	
	5	Construction work	Same	
	6	Storekeeper	Same	
	7	Order clerk	Schoolboy	
	8	Railroad watchman	Brakeman	
Amputation of the forearm	1	Salesman	Printer	Old man of 63
	2	None	Laborer	
	3	Fireman's helper	Factory work	Old man of 70
	4	None	Laborer	
	5	General work	Shipper	Earns more money
	6	Delivery clerk	Laborer	
	7	School	School	Does everything
	8	Contractor	Same	

TABLE 21—*Prosthetic Results*

	Amputations of the				Total
	Thigh	Lower Leg	Upper Arm	Forearm	
Patients alive and reporting	67	52	15	19	153
Wearing prostheses	45	44	2	4	95
Percentage using prostheses	67	85	13	21	62

In cases of amputations of the forearm, appliances were used a little more often than in cases of amputations of the upper arm and the appliances appeared to be of some practical benefit

Temporary prostheses were fitted in twenty-two cases and appeared to be of definite value in shortening the period between operation and the fitting of the permanent limb. The functional results were also better

In sixty-two cases the average time from operation until the delivery of the permanent limb was 9.3 months. This period is needlessly long. The best method of shortening the time interval is by the fitting of temporary prostheses. These were employed in twenty-two cases, and the average time until the permanent limb was fitted was seven months

# THE POSTOPERATIVE PROGNOSIS OF CANCER OF THE BREAST

REPORT OF A SERIES OF CASES STUDIED WITH REFERENCE TO  
THE RAPIDITY OF PROGRESS OF THE GROWTH PREVIOUS  
TO THE TIME OF OPERATION

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The end-results so far obtained in fifty-six patients with carcinoma of the breast on whom I have operated during the past twenty years are summarized in tables 1, 2 and 3. Except in case 40, all operations were typical complete excisions including the removal of the pectoral muscles and axillary glands. In all but four of the more advanced forms, sections were cut of the primary tumor and lymph nodes. Each patient has been traced either to date of death or to the condition at present, that is, in June or July, 1927.

In checking the results obtained in this small group of cases, I have reviewed most of the literature dealing with the late results following operations for cancer of the breast which has been published during the past fifty years. While opinions expressed in this paper will be based on the results observed in my own small series of cases, these opinions have in each instance been checked against the mass of data compilable from other sources.

The cases here reported have been grouped into three tables corresponding to the classification adopted by the Departmental Committee on Cancer of the British Ministry of Health.

Table 1 contains cases from class 1 of the British classification, i e., cases in which, so far as could be ascertained, the growth was entirely confined to the breast, the axillary glands not being invaded.

Table 2 contains cases from class 2, in which the axillary glands were already invaded but in which there was no evidence of involvement of any other contiguous or distant organ or tissue.

Table 3 contains cases from class 3 in which either the adjacent or distant organs or tissues were involved, e g., the pectoral muscles, the skin when ulcerated, the cervical glands, the opposite breast, etc.

My records show that fifteen cases belong in class 1, namely, cancers of the breast confined to the breast without demonstrable involvement of the axillary glands. As in other reported series, the results are, on the whole, gratifying. Eleven of the fifteen patients are still alive and free from recurrence. Six of the seven operated on more than ten years previously have lived from eleven to fifteen years after operation. Five of the six are still living, and one died of cancer fifteen years after operation.

leg trouble was experienced because the fibula had not been properly shortened. There were also several cases of amputation for sepsis in which closure of the wound had been attempted with the consequence that extensive infection had developed, and reamputation at a higher level had been required. This result might have been prevented if the original amputation had been of the open type.

In sixteen instances, it was necessary by reamputation to convert amputations of the lower leg into thigh stumps. In eleven cases, this was because of failure to arrest a gangrenous process by amputation in the lower leg. Five of these cases were of diabetic origin, three were due to arteriosclerosis and three to thrombo-angitis. In the remaining five cases, one reamputation was due to extension of sepsis, one was a primary amputation for tuberculosis which developed osteomyelitis of the tibia, and three were amputations for trauma in which reamputation was necessitated by ulceration of the stump in two instances and in the third by the development of gas bacillus infection in the sutured wound. In the latter case, it was necessary to amputate by the open method at midthigh. Experience shows that in diabetic and arteriosclerotic gangrene, it is practically always a mistake to amputate below the knee. The best operation in such cases is the Gritti-Stokes amputation. As a rule, difficulty in healing is not experienced and infinitely better functional results are obtained. In thrombo-angitis, on the other hand, on account of the younger age of the patients and the bilateral character of the process, it is better to amputate in the lower leg if the chances are fair.

There were two cases of secondary disarticulation of the hip joint following original amputations of the thigh. One of these was of traumatic origin and the amputation was in the upper third, leaving a stump too short for prosthetic purposes. Disarticulation was advised as a means of improving function, and this patient has achieved a satisfactory result with the aid of an appliance. In the other case, amputation was originally performed at midthigh for an enchondroma of the lower end of the femur. After four years, the tumor recurred in the stump, and disarticulation was then performed. The patient later died of metastasis.

There were three deaths among the cases of reamputations. These were cases of extending gangrene in elderly patients, two of diabetic and one of arteriosclerotic origin. The mistake was made of performing the primary amputation below the knee. The gangrene continued to spread, and it was then necessary to reamputate at midthigh. The deaths were due to senile complications. More than one reamputation was required in two cases. Additional stump operations were required in seventeen, but these were of localized character, and did not involve sacrifice of the length of the stump.

technic I am more than half inclined to suspect that some day it will be found that these results are due to factors about which, as yet, little or nothing is known

To suggest a line of investigation which may help to estimate the benefits, if any, to be expected in operations in cases in class 2, I have subdivided my cases into groups A, B and C. Group A is composed of what may be conceived clinically as highly malignant cases, because within four months or less after the discovery of the tumor more or less extensive axillary involvement was found at operation. Cases in

TABLE 2—Data of Cases in Class 2

Case Number	Group A	Preoperative Time, Months	Postoperative Time, Months	Present Condition
50		1	18	Satisfactory
51		1	8	Died of cancer
53		1	6	Died of cancer
45		4	18	Died of cancer
42		1½	37	Satisfactory
37		1	8	Died of cancer
34		1½	36	Died of cancer
32		2	8	Died of cancer
35		1½	72	Satisfactory
29		4	12	Died of cancer
22		3	3	Died of cancer
23		2	23	Died of cancer
14		4	146	No recurrence
12		3	42	Died of cancer
8		3	36	Died of cancer
2		4	108	Died of cancer
Group B				
20		6	24	Died of cancer
41		6	48	Recurrence
44		6	24	Satisfactory
47		12	24	Satisfactory
49		8	24	Satisfactory
43		12	36	Satisfactory
27		10	48	Died of cancer
16		24	84	Died of cancer
21		24	86	Died
15		12	24	Died of cancer
11		15	60	Died of cancer
Group C				
33		36	13	Died of cancer
28		30	108	Satisfactory
4		60	5	Died of cancer
3		48	66	Died of cancer

group B are arbitrarily suspected of being less malignant than cases in group A because, although glandular metastases may actually have been present as early as four months after the discovery of the tumor, there was on the whole an element of insidiousness about them that did not promptly force them to operation, when encountered from six months to two years after the tumors had been discovered, they still definitely belonged in class 2. Group C is conceived to be made up of cases showing a low grade of malignancy. This is justified by the fact that from two and a half to five years after the discovery of the tumor, they still belong in class 2.

surgical operation was not performed. The ages of the patients varied from 4 to 70 years, the average age for the entire group was 36 years. The majority of the patients were in the active, wage-earning period, and exposed to trauma by reason of their occupations. On the two extremes were the children and elderly persons who in the main received their injuries in accidents in which they were run over.

**Type of Injury** All of the patients requiring amputation because of trauma had received severe injury, usually of a direct crushing character. The majority had sustained partial amputations, the limbs being so extensively damaged that they could not be saved. Complete traumatic severance of the limb occurred in forty-four cases. In six cases amputation was necessitated by vascular damage with the development of gangrene a few days after injury. Many of the patients had complicating injuries, often multiple, of other parts of the body such as thoracic or visceral injuries, fractures of the skull or pelvis, or bones of the extremities.

**Shock** Surgical shock was present in most of the cases. In thirty-three cases, or 29.1 per cent, it was noted as especially severe. Such patients were kept on the heated shock table with the body tilted head downward until their condition improved. They were given large doses of morphine and received subcutaneous and intravenous infusions of saline. In the postwar period blood transfusion was employed in practically all cases as soon as donors could be obtained. This proved a potent life saving measure, and without question, is the most effective method of treating shock. Amputation of the injured limb was not performed until the patient had rallied from his state of shock, with the exception of a few cases in which the limb was attached only by a few shreds of tissue which could be divided without the necessity of an anesthesia and without moving the patient. In the few instances in which this rule was not followed, the patients died. The patient's condition was followed by frequent blood pressure readings. A falling systolic pressure or an initial pressure under 90 mm. mercury is an indication for blood transfusion. A rising pressure is favorable and when it reaches 100 to 110 mm. of mercury, it is usually safe to perform a quick amputation.

**Hemorrhage** Many of the patients had sustained severe hemorrhage, often arriving with a tourniquet in place. When it was necessary to use a tourniquet over a considerable time, the practice of releasing the pressure for a period of five minutes every hour was always followed. Whenever possible, the bleeding vessel was clamped off and the tourniquet removed, since pressure by a tourniquet may of itself occasion shock. In many of the complete traumatic amputations, the contusion of the tissues had sealed the vessels so that scarcely any hemorrhage occurred.

indicates a high grade of malignancy is, I believe, shown by the results in this group. Of the sixteen patients in this group, twelve are dead with an average postoperative life of only 2 14 years (or not quite two years and two months). Even this average is somewhat skewed by the presence of one patient who lived nine years after operation. This woman had extensive skin recurrences four years after operation. For some reason, these recurrent tumors regressed, and she remained comparatively well until shortly before her death nine years after operation. Four patients still survive twelve years and two months, six years, three years and one month and one year and six months after operation. The two patients still alive and free from demonstrable recurrences twelve years and two months and six years, respectively, after operation are the only ones in this group so far in whom operation seems to have prolonged life. I have never been able to account for the result in case 14, in which the patient was still alive twelve years and two months after operation. At the time of operation, a woman, aged 43, had an apparently rapidly growing, rapidly metastasizing tumor. I thought the prognosis was especially bad. Thirteen months after operation, she gave birth to a child which she nursed on the remaining breast. For the past three and a half years the right arm has been enormously swollen, but I have never been able to demonstrate any recurrence of the cancer, and her general health has remained good.

Group B of class 2 is composed of cases in which the patients came to operation between six months and two years after the discovery of the tumor. For reasons already given, this group is conceived of as being composed largely of only moderately malignant cases. If so, irrespective of any life-prolonging effects from the operation, one might expect a longer average postoperative period of survival than that obtained in cases in group A. Actually, the deaths occurred in this group 3 86 years after operation as compared with 2 12 years after operation in the cases in group A, and there was a total survival before death of nearly five years in cases in group B compared with less than two and a half years in cases in group A.

Group C of class 2 contained four cases in which operation was performed from two and a half to five years after discovery of the tumor. That they in general represent instances of a relatively low grade of malignancy is proved by the fact that even at the late period at which operation was performed they still remain in class 2. For the reasons already suggested in discussing classes A and B, one might expect, *a priori*, that some of these cases would show relatively long periods of postoperative survival irrespective of any question of complete or permanent cure. Small as this group is, it nevertheless contains two such examples. In case 28, operation was performed two and a half years after the discovery of the tumor, and the patient was



of the surgeon when in doubt to sacrifice this part in view of the excellent functional results that may be obtained with the aid of an artificial leg

**Type of Amputation** Figures were obtained as to the type of amputation in ninety-one of the 113 cases. Of these eighteen, or 19.6 per cent, were by the open or flapless method while seventy-three, or 81.4 per cent, were closed by suture. We hold the view that when the injury which necessitates amputation is situated at a useful prosthetic level, better results will be obtained, functional power conserved and postoperative complications rendered less frequent by the use of the open amputation. This should be performed at the level of injury with debridement of soiled and devitalized tissues. Secondary closure may be done when the

TABLE 25—*Traumatic Amputations, Distribution and Mortality*

Region	Distribution of Amputations		Mortality	
	Number	Percentage	Number of Deaths	Percentage
Forearm	27	23.9	0	0.0
Upper arm	23	20.3	3	2.6
Lower leg	37	32.7	6	5.3
Thigh	26	23.0	2	1.76
Totals	113	99.9	11	9.66

TABLE 26—*Distribution of Amputations for Sepsis*

Region	Number	Percentage
Forearm	2	4.7
Upper arm	0	0.0
Lower leg	17	40.4
Thigh	22	52.3
Hip	1	2.6

wound has been disinfected or, if this is not possible, a secondary operation may be performed at a later date with excision of scar and plastic closure of the skin. From a study of the results in these cases, we are of the opinion that the open amputation should have been used more frequently than it was.

**Amputations Due to Sepsis**—Next to trauma, sepsis was responsible for more amputations than any other cause. This group comprised thirty-five primary amputations and seven reamputations, a total of forty-two cases or 10 per cent, of the entire group. The distribution of the amputations is shown in table 26.

The striking fact about these figures is that the amputations of the lower limb outnumbered those of the upper extremity in the proportion of seventeen to one. There were only two amputations of the arm, both the result of severe septic infections of the hand, and both patients died. The majority of the amputations of the lower limb were due to osteo-

# MAJOR AMPUTATIONS

ANALYSIS AND STUDY OF END-RESULTS IN FOUR HUNDRED  
AND TWENTY CASES

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The following observations are based on an analysis and study of the end-result of 420 major amputations at the Massachusetts General Hospital. The group includes all the major amputations which were performed at this hospital from 1916 to 1926.

An idea of the frequency of amputation may be obtained by comparison of the total number of admissions to the hospital to the total number of operations performed during the same period. There were 65,476 admissions to the hospital, including both medical and surgical cases, the cases in which amputation was performed, therefore, represented 0.64 per cent of the total admissions. During the same period, 39,746 operations were performed, the amputations constituting a little more than 1 per cent of all the operations. Of the 420 cases in the group, primary amputation was performed in 360 and secondary operations or reamputations in sixty.

Table 1 shows the causes of amputation in this group of cases. It is interesting to note that amputations were not performed because of thermal or chemical injury. New England winters are fairly severe, but gangrene resulting from frostbite apparently is decreasing, probably due to more intelligent care of the feet and better methods of transportation.

Following amputation and prior to discharge from the hospital, forty-nine deaths occurred, an operative mortality of 11.6 per cent. In addition, there were ten cases of complete traumatic amputation in which the patient died soon after admission without operation being performed. The inclusion of these cases in the group would give a total hospital mortality of fifty-nine, or 16.3 per cent.

The causes of death are shown in table 2.

Table 3 shows the various postoperative complications which occurred in 420 cases of amputation.

In studying this table, it should be remembered that many of the conditions listed as complications merely represent the continuance of the original condition which necessitated amputation.

The distribution of the different amputations in respect to anatomic location is shown in table 4.

amputations who were discharged from the hospital, twenty-two have been heard from and seven have not been located. Deaths have not occurred so far as we could learn. Of the twenty-two patients examined, or heard from, seven have had secondary operations, four of which were performed because of persistent sinuses. Sixteen are using artificial legs, two are still using temporary appliances, one has a drainage sinus and cannot wear a leg, and the remainder are helpless, either because of age or poor physical condition. The economic status of the patients is the same as for amputations of the same type due to any cause.

*Endarteritis, Thrombo-Angutis, Raynaud's Disease*—This group, consisting of thirty cases and constituting 9.5 per cent of all those studied, includes all cases diagnosed as endarteritis obliterans, thrombo-angutis obliterans and Raynaud's disease. All the amputations were of the lower limb with the exception of three of the upper extremity, or 7.5 per cent. Of the thirty cases, reamputation was required later in eight. In addition, there were reamputations in ten cases in which the primary amputation had been performed elsewhere. There was a post-operative mortality of four, or 14.7 per cent. The ages of the patients ranged from 27 to 74 years, the average for the group being 44.2 years.

This group of cases is pathetic, the relief obtained from amputation being usually of short duration. The process extends, and sooner or later vascular disturbance develops in the opposite limb, or in the amputation stump, and the patient finally returns for further amputation. One patient has had thirteen amputations beginning with the fingers and ending at the middle of both thighs. Another has had seven amputations, still another five.

Eight of sixteen patients reporting for a study of end-result (table 28) show evidence of progression of the disease either in the stump or the opposite limb, and five have had double amputations. Eleven are using appliances to greater or lesser extent. Eight are able to follow the same or similar occupations. Seven patients are totally disabled, two owing to cardiac disease and three by reason of multiple amputations. One gets about a little as a dealer in junk. Two of the patients with bilateral amputations of the lower legs lead a surprisingly active life and are but little incapacitated.

Slow healing of the wound characterized most of these cases. When drains had been employed, the openings left after the removal of the drains often persisted as sinuses for many months, and in some cases, never healed. It is clear that drains should never be used in cases of this type. The amputations were usually performed by the equal flap method, and sloughing of the flap was of infrequent occurrence. As a rule, a tourniquet was not used. This is important as it allows the surgeon to judge the state of the circulation by the amount of bleeding, and

It will be noted that amputations of the upper extremity constitute only 21 per cent of the entire group, in contrast to 79 per cent for the lower extremity. This small figure reflects not only the more conservative attitude of the surgeon in regard to amputation of the upper extremity, but also the lesser incidence of grave pathologic processes here in comparison with the lower limb.

Table 5 shows the number of patients who had more than one limb amputated at one admission. Practically all of these cases were of traumatic etiology.

The duration of hospitalization may be taken as a fair index of the length of time required for convalescence from operations. This does

TABLE 4—*Types of Amputation (420 Cases)*

Type	Number	Percentage
Amputation thigh	155	37
Amputation lower leg	152	36
Amputation forearm	43	12
Amputation upper arm	30	7
Gritti Stokes amputation	13	3
Disarticulation hip	9	2
Disarticulation shoulder	8	2
Syme amputation	6	1.4
Amputation through tarsus	3	0.7
Disarticulation knee	1	0.2
	420	

TABLE 5—*Multiple Amputations at One Admission*

Limbs Amputated	Number of Cases
Both thighs	5
Both lower legs	2
Upper arm and thigh	1
Forearm and lower leg	1
Both lower legs and one forearm	1
	11

not refer to complete healing of the wound, as many of the patients required surgical dressings after leaving the hospital. It implies, however, that the wound was small enough to be safely handled in the outpatient department. Table 6 shows the period of hospitalization for the principal amputation groups, including both open and closed wounds.

The number of open and closed amputations in this group of cases, also the frequency of the use of drainage materials are shown in table 7.

It is always a matter of judgment whether an amputation wound should be closed or left open, and in the former case, whether or not drains should be inserted. In this group of cases, the open type of amputation has usually been employed when the amputation was performed for acute infection. When the infection was chronic or of a low grade of virulence, or situated at a considerable distance from the level of amputation, the wound has sometimes been closed loosely, drains

extensive tuberculous involvement with multiple sinuses was present, but secondary pyogenic infections as well. They were cases in which conservative treatment had been thoroughly tried and had failed, and in which the general health was being seriously undetermined by the local lesion. Many of the patients were also suffering from advanced pulmonary lesions. In all of the cases the diseased member had long since ceased to have any functional value. In the case of the amputations of the arm, it was only the hopelessness of further conservative treatment that led to the final determination to amputate.

In respect to tuberculous lesions of the tarsal joints and ankle in adults, the policy has been different. Here amputation at the middle of the leg has usually been performed as a matter of election. The orthopedic service, which has been responsible for the treatment of most of these patients, has taken the view that when the tuberculous character of the lesion is proved beyond doubt, usually by inoculation of a guinea-pig with aspirated fluid or examination of tissue removed by exploratory incision, then amputation is the treatment of choice. The social and economic conditions surrounding the patients have been the determining factors. The patients treated are wage earners with dependent families and cannot afford long periods of disability. Under the most favorable circumstances a cure cannot be expected from conservative treatment in less than two years, usually longer. The chances of failure are great, and even when successful functional impairment of greater or lesser extent is to be expected. On the other hand, the functional result from a midleg amputation with a good stump is excellent, and the patient ought to be able to do as much work as if a successful result was obtained from conservative treatment. The saving of time is of decisive importance, and in addition there is the improvement in health which may be expected to follow the complete removal of the focus of the disease. It is to be understood, however, that this policy does not apply in the case of children or adolescents in whom the conditions for obtaining a cure are much more favorable and in whose cases the time element is of little importance.

The end-results of amputations for tuberculosis are shown in table 30. Of the thirty-four patients whose cases have been followed up, sixteen have died, or practically 50 per cent. All of these deaths have been due to tuberculous lesions of various types, with the exception of one from septicemia, one from cerebral hemorrhage and one from an unknown cause. Even these diagnoses do not exclude the possibility that death has been due to tuberculosis. Five patients are living, but are under treatment at present for active tuberculosis. In some of the cases new lesions have developed since amputation. Only thirteen of the thirty-four patients who have been traced are alive and apparently well.

infection of the wound occurred in forty-nine, or 19 per cent. This is a high incidence and can probably be explained on the ground of reluctance on the part of some surgeons to use the open type of amputation in cases of infection, and the attempted closure of wounds which would have done better if left open.

We have a strong feeling that drains often are needlessly inserted in clean amputation wounds. If bleeding is carefully arrested, there is no more reason for the use of drains than in clean operative wounds elsewhere. We are convinced that many of the persistent sinuses which are prevalent in amputation wounds are the direct result of infection which has gained entrance along the drain tract. This might not occur if the drains were removed as a routine at the end of from twenty-four to forty-eight hours, unfortunately, they are usually allowed to remain

TABLE 9—*Wound Healing in 254 Closed Amputations*

	Percentage of Each	Thigh	Lower Leg	Upper Arm	Forearm	Total
Healed by first intention						
With drainage	37.1	30	12	16	10	68
Without drainage	42.2	18	11	1	0	30
Healed by granulation						
With drainage	32.2	22	26	4	7	59
Without drainage	32.5	8	14	0	1	23
Frank wound infection						
With drainage	20.2	14	16	3	4	37
Without drainage	16.9	7	3	1	1	12
Not healed at discharge						
With drainage	10.3	1	16	0	2	19
Without drainage	8.5	3	3	0	0	6
Secondary closures <sup>a</sup>		3	6	2	0	11
Skin grafting required		0	4	0	2	6

much longer. When infection is feared, it is a better policy to leave the stump open than to close with drainage. Infection of the wound in a closed stump delays convalescence enormously, and almost invariably necessitates reamputation later. There is a sacrifice of stump length at the time of the original amputation in order that the flaps may be formed from clean tissues, and the reamputation entails still further loss. The open amputation, on the other hand, can be performed at the lowest possible level, and although a secondary operation is usually required, this need not be a formal reamputation. It conserves function, and the results are so good that there would not seem to be any justification for the policy of closure with drainage. The rule ought to be either to close tight or to leave wide open in all but exceptional cases.

Table 9 shows the wound complications in the cases of closed amputations. It will be noted that the figures are slightly but almost uniformly better in the cases in which drainage is not used.

below the knee Two of these patients died The other reamputations were performed because of unsatisfactory stumps In addition, two patients had bilateral amputations of the legs at different admissions

The best treatment for diabetic gangrene is by prevention, as has been pointed out by Joslin,<sup>2</sup> and much may be accomplished along this line Infection is apparently the match which lights up the process, and this must be avoided at all costs Every diabetic patient should be informed of the danger of gangrene and advised of the necessity of daily bathing of the feet, of wearing clean hose, of obtaining shoes of correct shape and ample size in order to eliminate corns and ingrowing toe nails of performing routine exercises and finally, of seeking proper surgical care whenever an abrasion of the skin develops

TABLE 31—*End-Results in Amputations for Diabetic Gangrene*

Number of cases of primary amputation		36
Died in hospital following amputation	12 or 33.3%	
Diabetes	5	
Bronchopneumonia	3	
Septicemia	2	
Uremia	1	
Pulmonary embolism	1	
Died since leaving the hospital	11 or 30.5%	
Diabetes (11 months, 1½ years, 3 years postoperative)	3	
Cerebral hemorrhage (6 months, 3 years postoperative)	2	
Myocarditis (5 years postoperative)	1	
Carcinoma of breast (1½ years postoperative)	1	
Septicemia (1 year postoperative)	1	
Cause not stated (3 weeks, 1 year, 1½ years postoperative)	3	
Alive but incapacitated from diabetes	2 or 5.5%	
Alive and apparently well	2 or 5.5%	
Not located	11 or 30.5%	

If gangrene appears, amputation should usually be performed early to prevent extension of infection Amputation of the digits is rarely of any avail except in limited infections or localized areas of ulceration or gangrene Amputation at the junction of the middle and upper thirds of the lower leg is indicated when the patient is in good general health, pulsation present in the popliteal artery and the infectious process well localized When the patient is elderly or shows evidence of extensive arteriosclerosis, even though the gangrene involves only the forefoot, nothing short of amputation above the knee will suffice, and the Gritti-Stokes amputation provides the best stump in such cases when it can be performed When the entire foot is affected, amputation above the knee should be performed In five of our diabetic patients the mistake was made of amputating below the knee, with the result that the gangrene extended, reamputation above the knee became necessary, and two of the patients died

<sup>2</sup> Joslin, E P Treatment of Diabetes Mellitus, Philadelphia, Lea & Febiger, 1923

of a boy who had an osteogenic sarcoma of the femur. Disarticulation of the hip was performed and he is alive and well at the end of two years without any sign of recurrence or metastasis.

Only one of these three patients uses an artificial leg. He is a teacher in an agricultural college, and has to walk and be on his feet a great deal. He walks with little apparent limp and carries his heavy prosthesis without difficulty. The other two patients rely entirely on crutches. The boy has not been fitted with a leg because he is growing, and the parents are unable to bear the expense of the frequent refitting which would be necessary. He has become so agile on crutches that he probably will never attempt to use a limb. The third patient had not been able to use his diseased leg for twenty years previous to amputation. He had become entirely accustomed to crutches and decided that a prosthesis would be a handicap rather than a help.

TABLE 11—*Causes of Death After Leaving Hospital*

Tuberculosis	11	Septicemia	1
Cerebral hemorrhage	9	Appendicitis	1
Carcinoma	5	Uremia	1
Sarcoma	8	Acute nephritis	1
Diabetes	3	Chronic nephritis	1
Myocarditis	3	Burns	1
Cardiac decompensation	1	Suicide	1
Arteriosclerosis	2	Not stated	4
Angina pectoris	1		
			54

All three of these patients have continued at the same occupation they followed before disarticulation was performed. One works as assembly man in a factory manufacturing bankbooks, one is a teacher, and the third is a school boy. Neither of the adults has sustained any economic loss as the result of the loss of the leg, and the boy will be trained for some work within his physical capacity.

*Amputation of Thigh*—Amputation of the thigh was performed in 155 cases, or in 37 per cent of the entire group of patients. There were twenty-three postoperative deaths, or a mortality of 14.8 per cent. Of those surviving, sixty-seven are living and have been heard from. Forty-five, or 67 per cent, are using artificial limbs, eighteen of these have been personally examined, the length of the stump measured in relation to the length of the normal femur, and accurate notes made of the functional result (table 12). It will be noted that the percentage of poor functional results was largest in amputations in the upper third (three of five), next largest in amputations in the middle third (three of eight), while in the lower third, poor results were not observed.

In most cases of amputation of the thigh in which an artificial limb was not worn it was because of disease or debility such as cardiac weak-



original amputation below the knee had been a mistake. The fourth reamputation was performed in a case in which primary traumatic amputation had been performed many years before, and in which gangrene subsequently developed in the stump of the lower leg, so that reamputation above the knee was necessary. On the whole, the evidence obtained from study of this group justifies the conclusion that arteriosclerotic gangrene always necessitates amputation above the knee. The blood supply in the region of the knee is usually abundant even in these cases, and both from the standpoint of actual clinical experience and from a knowledge of the functional results that may be obtained, we advise the Gritti-Stokes amputation whenever possible.

The end-results have been ascertained in sixteen of the twenty-eight patients discharged from the hospital (see table 33). Six have died within two years of the operation, two are alive but suffering from auricular fibrillation, and eight are alive and apparently well. The func-

TABLE 33—*End-Results in Amputations for Arteriosclerotic Gangrene*

Number of cases of amputation		20
Died in hospital following amputation		
Bronchopneumonia	3	8 or 22.2%
Causes undetermined	4	
Septicemia	1	
Died since leaving the hospital		6 or 16.6%
Arteriosclerosis (6 months, 1½ years, 2½ years postoperative)	3	
Cerebral hemorrhage (3 weeks, 7 months postoperative)	2	
Chronic nephritis (2 years postoperative)	1	
Alive but suffering from auricular fibrillation		2 or 5.5%
Alive and apparently well		8 or 22.2%
Not located		12 or 33%

tional results are poor because of old age and feebleness. Only a few are making use of appliances. Of the twenty-four patients whose cases have been followed, fourteen, or 58 per cent, are dead, two are incapacitated, and only eight, or 33 per cent, are in good health. However high this mortality may appear, it is doubtful if it is much above what should be expected in a group of persons of similar age.

**Sarcoma**—Thirty amputations were performed for sarcoma, representing 71 per cent of all amputations studied. Twenty-eight of these were primary amputations, one was a reamputation, and one was a case of multiple amputation at separate admissions which has been counted twice. The average age for the group was 31.4 with extremes of 10 and 69 years.

The classification of the tumors and their location are shown in table 34, also the results so far as it has been possible to ascertain them.

The amputations were distributed as follows: thigh, twenty-one; lower leg, three; and upper arm, six. Amputations of the thigh were performed in fourteen cases of tumor of the femur, in one of fibrosarcoma of the thigh, and in six of seven cases of tumor of the tibia the

Some excellent results were noted. Three are able to walk a distance of from two to three miles, and several work at jobs which necessitate standing all day. The best results were seen in patients with stumps of good length, in which healing had occurred by first intention. Two of the best results noted in patients on whom the Gritti-Stokes amputation had been performed and who had been fitted with full end-bearing legs. One of these patients was working as a machinist, the other as a labor gang foreman, there was scarcely any disability in either case.

TABLE 14—Occupations of Persons on Whom Amputations of the Thigh Was Performed

Working—17 Patients, 53 per Cent		
Number	Present Occupation	Former Occupation
1	Tanitor	Traight brakeman
1	Shoe factory, machine operator	Same
1	Shoe factory, fitter	Housework
1	Factory employee	Tailor
2	Odd jobs	Coal helper, lunch counter
1	Auto mechanic	Same
2	Student	Same
1	Clerk	Same
1	Cobbler	Factory worker
1	Pedler	Laborer
1	Dressmaking	Same
1	Draftsman	Student
1	Machinist	Same
1	Labor foreman	Laborer
Not Working—15 Patients, 47 per Cent		
Reason for Not Working		Former Occupation
9	Scillity in various forms	Farm laborer 2
		Laborer 1
		Blacksmith 1
		Farber 1
		Card shop 1
		Cool 1
		None 2
1	Poor circulation in legs (endarteritis)	None
1	Osteomyelitis, multiple foci	School boy
1	Painful stump	Housework
1	Receiving industrial compensation	Laborer
1	Cannot walk with leg	Painter
1	Diabetes	Tailor

*Amputations of the Lower Leg*—There were 152 amputations of the lower leg or 36 per cent of the 420 cases. There were ten deaths, a postoperative mortality of 6.5 per cent. Fifty-two of the surviving patients are still alive and have been heard from, the rest have either died or not been located. Forty-four, or 85 per cent, are wearing artificial legs, a much better showing than in amputations of the thigh where the proportion was only 65 per cent. It was found that no patient who was well enough to walk went without prosthesis.

The functional results were usually better than in cases of amputation of the thigh. Several of the patients said that they could walk any distance, and twenty-eight of thirty-three on whom occupational notes were made were working, fifteen at the same job as before amputation. Several of the occupations involved heavy work, two patients being

roentgen ray The ages of the patients varied from 36 to 65 years, with an average of 53.7 years The amputations were distributed as follows lower leg, four, thigh, three, forearm, three, and upper arm, one

There were no deaths as a result of operation and no reamputations Three of the eleven patients have died since leaving the hospital, one of

TABLE 35—*End-Results in Amputations for Sarcoma*

Number of amputations for sarcoma	30
Reamputations because of recurrent tumor	1
Secondary amputations of opposite limb	1
Total cases	25
Died in hospital following amputation	0
Died since leaving hospital	11 or 40%
Metastatic sarcoma (2 cases 4 months, 6 months, 8 months, 1 year, 2 years, 2½ years, 7 years postoperative)	8
Appendicitis (17 months postoperative)	1
Cerebral hemorrhage (8½ years postoperative)	1
Not stated (1½ years postoperative)	1
Alive, but have recurrence or metastases	3 or 11%
Alive and clinically well	8 or 28%
Osteogenic sarcoma, shaft of humerus, 6 years postoperative	
Osteogenic sarcoma, shaft of humerus, 1½ years postoperative	
Osteogenic sarcoma, lower end of femur, 5 years postoperative	
Osteogenic sarcoma, shaft of femur, 3 years postoperative	
Sarcoma, unclassified, lower end of femur, 6½ years postoperative	
Sarcoma, unclassified, lower end of femur, 8 years postoperative	
Giant cell tumor, upper end of tibia, 10 years postoperative	
Angiosarcoma, dorsum of foot, 1 year postoperative	
Not located	6 or 21%

TABLE 36—*End-Results of Amputations for Carcinoma*

	No of Cases	Post-operative Period	Dead	Alive and Well	Alive but Show Recurrence	Not Located
Metastatic hypernephroma	1	2½ yrs	1	0	0	0
Epithelioma, amputation stump, foot	1	1½ yrs		1	0	
Epithelioma of hand, metastases to axilla	1	9½ yrs				1
Epithelioma of hand	1	9 yrs				1
Epithelioma of fingers, metastases to axilla	1	8½ yrs	1			
Epithelioma of thigh	1	1½ yrs		1		
Epithelioma of hand	1	10 mos	1			
Epithelioma of lower leg	1	5 yrs		1		
Epithelioma of foot	1	1 yr		1		
Epithelioma of hand	1					1
Epithelioma of hand	1					1
Totals	11		3	4	0	4

uremia and two of metastatic carcinoma (table 36) Of the latter, one died two and one-half years after amputation, and the other eight and one-half years, four of the patients are clinically well, and four have not been found

*Thrombosis and Embolism*—There were ten amputations in nine cases on account of thrombosis and embolism, 23 per cent of the entire series All of these were in elderly patients Three cases were diagnosed embolism and the remainder thrombosis In two cases of throm-

*Syme Amputation*—The value of the Syme amputation in properly selected cases is demonstrated by a study of the end-results. There were six of these cases in which death did not occur, all the patients have been traced. The amputation was a failure in one because of improper selection. This patient was a boy, aged 9, who had spastic paraplegia and paralytic equinovarus deformity of both feet and trophic ulcers caused by spina bifida. There were areas of cutaneous anesthesia involving both feet and lower legs, also involvement of both vesical and rectal sphincters. After a long period of unsuccessful orthopedic treatment, bilateral Syme amputations were performed. The boy later developed trophic ulcers on the ends of the stumps when weight bearing was begun. Amputation of the mid leg was performed on one side and two years later the same procedure became necessary on the other side. The boy

TABLE 16—*Prosthetic History Amputation of the Lower Leg*

Using artificial leg		20
Good function, no difficulties experienced	24	
Have used artificial leg but complain of difficulties as follows:		
Sore on stump	1	
End of stump sensitive	1	
Leg too heavy for stump	1	
Chafes	1	
Fit of leg unsatisfactory	2	
Have had to change leg as follows:		9
Socket changed twice	2	
Have had to buy new leg	6	
Leg replaced twice	1	
Fitted with provisional appliance		13
Average time from operation to receiving temporary appliance	35 months	
Average time from operation to receiving permanent leg:		
When provisional appliance had not been used	95 months	
When provisional appliance had been used	82 months	
Average time saved	13 months	

died of uremia. This case illustrates the necessity of normal innervation of the skin at the end of the Syme stump if a successful result is to be obtained. The virtue of the Syme amputation lies wholly in the complete end weight bearing ability of the stump. If this result is not obtained, then amputation of the mid leg is preferable.

In the remaining five cases Syme amputation was performed because of the following lesions: tarsal tuberculosis, two cases, unsatisfactory Chopart amputation, one, painful and contracted foot resulting from burns, one, and hemiplegia with intractable deformity of foot, one.

The results in all cases were successful as regards complete end-weight bearing ability. All of the patients were able to walk across the room on the bare stump. Four were fitted with end-weight bearing appliances, the fifth obtained his artificial limb without medical guidance and was given an improper type of leg which does not utilize end-bearing. One patient required a secondary operation because of a painful exostosis at the end of the fibula.

femur in a tabetic person, in a second case of fracture of the tibia in a man, aged 56, with syphilitic osteitis, in a third case an ununited fracture of the femur with failure to obtain union after four years of conservative treatment and in a fourth case of osteomyelitis with failure of union following spontaneous fracture. No deaths occurred while the patients were in the hospital, although one of the patients died after discharge. The three remaining patients are alive and in good health.

**Ruptured Brachial Plexus** (Three cases, three amputations, 0.7 per cent) Amputation of the humerus or disarticulation of the shoulder was performed in three cases of traumatic rupture of the brachial plexus with complete paralysis of the arm. Each of these cases was of several years' duration, and reparative operations had been performed without success. The amputation was performed in each instance at the patient's request. In two cases this was because of obstinate and severe nerve pain, in the

TABLE 38—*End-Results of Amputations for Miscellaneous Conditions*

Condition	Number of Cases	No Amputation	Post operative Deaths	Deaths Since Leaving Hospital	Patients Alive	Not Found
Gas bacillus infection	8	8	3	0	4	1
Ununited fracture	4	4	0	1	3	0
Ruptured brachial plexus	3	3	0	1	2	0
Spina bifida	1	3	0	1	0	0
Charcot joint	1	2	0	0	1	0
Foot deformity	1	1	0	0	1	0
Trophic ulcer	1	1	0	0	1	0
Tetanus	1	1	1	0	0	0
Pressure of pelvic tumor	1	1	0	1	0	0
Ligation for aneurysm	1	1	0	0	1	0
	22	25	4	4	18	1

third because the arm represented a useless and constant source of annoyance. In one of the cases in which pain was present the patient was relieved, in the other case, he was not. In the latter, injection of alcohol into the nerve roots was subsequently performed, and later an interthecal division of the dorsal roots, without much improvement. This patient died of nephritis, the other two are living and well.

**Spina Bifida** (One case, three amputations, 0.7 per cent) This was a case of paraplegia due to spina bifida with equinovarus deformity of the feet and trophic ulcers. Bilateral Syme's amputation was performed, but trophic ulcers appeared on the stumps, and it was subsequently necessary to amputate at midleg.

**Charcot Joint** (One case, two amputations, 0.4 per cent) Amputation was first performed at midleg because of a Charcot ankle. Later a Charcot arthropathy developed in the opposite knee, and it was necessary to amputate in the lower third of the thigh. This patient gets around well with his appliances and is able to earn a living.

of the upper arm. Death could not be ascribed to the amputation in any case, although several patients died as a result of the original disease process.

Only two of the fifteen patients who had the upper arm amputated are using appliances. One of these is employed as a clerk in a shipping house and derives some practical benefit from his prosthesis. The other does not have an occupation and wears his appliance presumably for cosmetic reasons. Only four of the nineteen patients who had the forearm amputated, use appliances. Two of these use prostheses of the split hook type, but only part of the time, the rest of the time they use nothing. The other two wear artificial hands. The occupations of these four men are contractor, one, elevator operator, two, and sales clerk in store, one.

Apparently the length of stump made little difference as far as the functional results was concerned. The uninjured arm was depended on almost altogether and made to do the work of two. In the amputations

TABLE 19—Occupations in Double Amputations of Lower Extremities

Level	Number	Present Occupation	Former Occupation	Reason for Not Working
Amputation of both thighs	4	None	None	Total disability
Amputation of thigh and lower leg	1	Bead making at home	Laborer	No prosthesis does not walk
Amputation of thigh and lower leg	1	Spanish correspondent	Salesman	
Amputation of both lower legs	1	None	Laborer	Endarteritis
Amputation of both lower legs	1	None	None	Senile debility
Amputation of both lower legs	1	Agency work	Car Inspector	
Amputation of both lower legs	1	Laborer	Same	
Total	10			

of the forearm the stump was used considerably to aid the normal hand in the performance of certain tasks. In amputations of the upper arm the stump was used little.

In respect to occupation, all either did not have an occupation or did work, which did not require the use of two hands. The class of work, however, done by the patients whose forearm had been amputated was in general a little more difficult than that done by those whose upper arm had been amputated. The occupations, when known, are shown in table 20.

From the little use that was made of appliances in this group of thirty-four cases, it would seem evident that small weight should be given to prosthetic considerations in determining the point at which an amputation of the upper extremity should be performed. Cure of the original disease process and obtaining a painless nonsensitive stump are the chief goals to be sought.

*Prosthetic Summary*—In amputations of the thigh most patients who were able wore artificial legs. When these were not used, it was gen-

length of the stump Drains are often used needlessly, and many persisting sinuses can be traced to this cause

*Functional Results*—Sixty-seven per cent of the patients with amputations of the thigh used appliances The longer the stump the better were the results obtained Much benefit was noted from the use of temporary prosthesis The average time between the operation and the delivery of the permanent limb was 13.3 months when temporary prosthesis had not been used, but when one had been fitted, this period was shortened to 5.5 months Fifty-three per cent of the patients with amputations at the thigh were employed

Eighty-five per cent of the patients with amputations of the lower leg used appliances The functional results were usually better than after amputations of the thigh, although a larger proportion of the patients complained of stump disabilities The temporary prosthesis was of benefit, but its use reduced the time interval between operation and the delivery of the permanent limb less than in the case of amputations of the thigh

The results of the Syme amputation were satisfactory in five of six patients All had stumps capable of direct end-bearing, and the majority were doing heavy work

In patients in whom amputations of the upper extremities had been performed, the length of the stump made little difference as far as the functional result was concerned Appliances were used by only six of thirty-four patients Seventy-eight per cent of the patients in whom amputations of the upper arm had been performed were working, but the occupations were of a type which did not require the use of both hands On this showing, it would appear that little heed should be given to prosthetic considerations in determining the level of amputation in the upper extremity

*Reamputations*—Of the 360 primary amputations performed at the Massachusetts General Hospital, reamputation was required in fifty-three cases, or 14.7 per cent First intention healing was obtained in only 42 per cent Painful nerve bulbs constituted an unimportant cause of reamputation This result is probably to be attributed to the employment of the alcohol injection technic The most common cause of reamputation was ulcer of the stump Amputations of the lower leg had been performed on seventeen of twenty-one patients with ulcerated stumps and amputations of the thigh on four In eleven patients it was necessary to reamputate above the knee because of extending gangrene following a primary amputation of the lower leg

*Disease Groups*—Traumatic amputations were twice as common as amputations from any other cause These were distributed fairly evenly between the two segments of the upper and lower limb Trauma

## REAMPUTATIONS AND SECONDARY OPERATIONS

Of the 420 cases of amputation included in our study sixty-nine, or 16.4 per cent, were classified as reamputations. This term is often used inexactly to denote any operation on an amputation stump irrespective of its nature, and it is probable that some cases were included among our cases of reamputation in which only local operations had been performed, such as sequestrectomy, excision of neuroma or resection of painful scar. It was sometimes difficult to determine from the records exactly what had been done.

The causes for which reamputation was performed are shown in table 22. Study of this list shows that many of the conditions were unavoidable and that they were often to be attributed to the circumstances under which the original amputation had been performed. Such were some of the cases of osteomyelitis, adherent scar and unsatisfactory

TABLE 22—*Causes of Reamputation (69 Cases)*

Causes	Thigh	Lower Leg
Stump unsuitable for prosthesis		
Osteomyelitis with sinus	2	2
Ulcer on end of stump	4	17
Neuroma end of stump	1	0
Painful (not described)	3	1
Adherent scar	1	1
Exostoses on stump	1	2
Retracted flaps bones under skin	1	2
Deformity of foot	0	1
Unsatisfactory, cause not stated	2	3
Extending gangrene		
Thrombo angilitis	0	3
Diabetes	0	1
Arteriosclerosis	0	"
Extensive sepsis in wound	3	5
Recurrent sarcoma	1	0
Gas bacillus infection	0	1
Carcinoma	0	1
	19	50

stump covering which resulted from open amputations. The necessity of a secondary operation in such cases does not reflect on the surgeon who performed the primary amputation. It has been a great satisfaction to note that so little trouble was experienced from the development of painful neuromas. The good results here are to be ascribed to the fact that the technic of Huber and Lewis<sup>1</sup> for injection of alcohol was adopted at the Massachusetts General Hospital in 1919, and that it has been used in practically all cases of amputations since that time.

On the other hand, many of the reamputations were the result of mistakes in judgment or technic and might have been prevented. Among these were several amputations in the lower third of the lower leg. Such amputations give trouble almost invariably—the end of the stump lacking proper blood supply and tending to become cold, cyanotic and sensitive and later, to ulcerate. In several other cases of amputation of the lower

<sup>1</sup> Lewis and Huber. Amputation Neuromas. Arch. Surg. 185 (July) 1920.



# RELATION OF THE PARATHYROIDS TO THE HEALING OF A FRACTURE AS CONTROLLED BY THE ROENTGEN RAYS\*

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Since Sandstrom's discovery of the external parathyroids in 1880 the parathyroid glands have been discussed extensively.

There are two schools of thought, one being that these glands influence calcium metabolism, and the other that they exert a detoxicating effect on guanidin bodies. The balance of opinion seems to favor the former, and in 1925, definite evidence as to their influence on calcium metabolism was established by Collip,<sup>1</sup> and by Collip, Clark and Scott.<sup>2</sup>

While engaged in an attempt to produce by means of partial parathyroidectomies a condition in the bones of experimental animals analogous to idiopathic osteopsathyrosis in man, it occurred to me that it would be interesting to note the effect of parathyroidectomy, partial or complete, on the healing of fractures.

Morel<sup>3</sup> (1909-1910) working with cats, and Canal (1919) working with rats, asserted that removal of the parathyroids causes a delay in the healing of fractures. The recorded experiments of these authors, however, leave one in doubt as to the amount and nature of the tissue removed.

Ogawa<sup>4</sup> (1925) published the results of a chemical analysis of the callus deposited at the site of fractures in rats which had had their parathyroids either entirely or almost entirely destroyed by cauterization. He found that the calcium content of the callus was decreased in these animals as compared with his controls. He further adduced that destruction of the thyroid did not have any deleterious effect on the healing of fractures.

In 1926, I decided to repeat the experiments of these men, using more elaborate precautions. Thus it seemed necessary to study the effect of excision of different amounts of parathyroid tissue, to verify the condition of the fracture at different intervals by roentgen-ray examination, and to make determinations of the blood calcium during the course of the several experiments.

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\* From the Department of Physiology and Experimental Medicine, McGill University. The expenses of this research were defrayed by the Percy Cowans Scholarship.

1 Collip J Biol Chem **63** 395, 1925

2 Collip, Clark and Scott J Biol Chem **63** 439, 1925

3 Morel Compt rend Soc De Biol **68** 163, 1910

4 Ogawa Arch f exper Path u Pharmacol **109** 83 1925

Most of the results from reamputation were satisfactory. Considerable difficulty was experienced with the wounds, only twenty-eight, or 42 per cent, healing by first intention (table 23). This was the result of the low grade sepsis present in many of the cases. Two reamputations were of the open or flapless type, one due to gas bacillus infection, and the other to pyogenic infection.

In twenty of the cases in which reamputation was required, the primary amputation had been performed elsewhere, in the remaining forty-nine cases both the primary and secondary amputations had been performed at the Massachusetts General Hospital. In addition, it was

TABLE 23—Results of Reamputation (69 Cases)

Open amputations (healed by granulation)	2
Closed amputation wounds	67
Healed per primam	25 or 12.1%
Healed by granulation	25 or 37.5%
Not healed at discharge	8 or 12.1%
Died of extending gangrene (2 diabetic and 1 arteriosclerotic with other complications)	3
	69

TABLE 24—Distribution of Reamputations with Reference to Primary Amputations

Primary Amputation Elsewhere		Reamputation Massachusetts General Hospital	
Thigh 0	Lower Leg 20	Thigh 2	Lower Leg 18
Primary Amputation Massachusetts General Hospital		Reamputation Massachusetts General Hospital	
Thigh 12	Lower Leg 27	Thigh 23	Lower Leg 16
		Local operations 8	
Primary Amputation Massachusetts General Hospital		Reamputation Elsewhere	
Thigh 3	Lower Leg 1	Thigh 3	Lower Leg 1

found by inquiry concerning the cases which had been followed up that four patients on whom primary amputation had been performed at the the Massachusetts General Hospital had later had secondary operations performed elsewhere. Therefore, of the group of 360 primary amputations, later reamputation was required in fifty-three or 14 per cent.

#### END-RESULTS WITH REFERENCE TO DISEASE GROUPS

*Amputations Due to Trauma*—In the group of 360 primary amputations, 113, or 26.9 per cent, resulted from trauma, more than twice the number due to any other cause. This represents only the cases in which surgical amputations were performed. In addition, there were ten patients with complete traumatic amputation who died shortly after arriving at the hospital. These were not included in the group because

Feb 5 The injured limb was used readily and with little perceptible limp. There was a definite deposition of callus, as shown by a roentgenogram.

The animal was killed on this day and sections made of the remaining thyroid, in which two parathyroids were found. No trace of other parathyroid tissue was present. At no time between January 15 and February 5 did the blood calcium go below 10 mg per one hundred cubic centimeters of serum.

*Cat B*—Jan 15, 1926. A young female cat was used. The blood calcium was 10.5 mg per hundred cubic centimeters of serum. Thyroparathyroidectomy was performed on the left side and external parathyroidectomy on right side, i. e., three parathyroids were removed.



Fig 1—External parathyroid in a cat

The left radius and ulna were fractured. A starch bandage was applied.

Jan 17 The bandage was removed. The cat appeared more sickly than cat A, but there was no evidence of tetany. She moved about the cage with the left leg held off the floor and took a little food.

Jan 19 The blood calcium was 8.7 mg per hundred cubic centimeters of serum.

Jan 22 The leg was still held off the floor when walking. The cat ate quite well.

Jan 29 A roentgenogram did not show any evidence of callus. The blood calcium was 8.7 mg per hundred cubic centimeters of serum.

Jan 31 One gets the impression of there being a pseudo-arthritis at the site of the fracture.

Feb 5 There was still no evidence of callus shown by the roentgen-ray. The blood calcium was 8.5 mg per hundred cubic centimeters of serum.

It was often difficult, except on the basis of the history, to differentiate between pure surgical shock and shock due to hemorrhage.

**Mortality** There were eleven deaths in the group of 113 traumatic amputations, a mortality rate of 9.66 per cent. Five of the patients who died had had amputations of more than one limb. All of these were cases of extreme trauma, and if they are subtracted from the rest, it leaves a mortality rate of 5.3 per cent which is surely low for this type of injury, and evidence that the cases were well treated.

This does not include ten patients who died almost immediately after admission to the hospital. The injuries responsible for the rapidly fatal termination in these particular cases are listed as follows:

1 Complete traumatic amputation of the upper arm and the lower leg, profuse hemorrhage. The patient died in shock soon after admission.

2 Complete traumatic amputation of the thigh, profuse hemorrhage. The patient died in shock soon after admission.

3 Complete traumatic amputation of the left upper arm, fracture of the left femur, fractured pelvis and perineal lacerations. The patient died in shock ten hours after admission.

4 Crush with partial amputation of the right thigh, right forearm, evulsion of scrotum. The patient died in shock two hours after admission.

5 Complete traumatic amputation of the left upper arm, open dislocation at knee, compound fracture of the right tibia. The patient died in shock soon after admission.

6 Complete traumatic amputation of both feet, fractured skull, ruptured viscus. The patient died soon after admission.

7 Complete traumatic amputation of the right lower leg, multiple fractures, contusions, and lacerations. The patient died soon after admission.

8 Complete traumatic amputation of the left leg at thigh and left arm at shoulder, right foot crushed. The patient died in shock soon after admission.

9 Partial traumatic amputation of the left thigh, fractured skull. The patient died in shock four hours after admission.

10 Complete traumatic amputation of both thighs, fractured skull. The patient died ten minutes after entry.

**Distribution** The distribution of the traumatic amputations is shown in table 25. It is to be noted that in the entire amputation group there were only eighty-one amputations of the upper extremity, comprising approximately 20 per cent, of these trauma was responsible for fifty or 61.7 per cent. Table 25 shows a comparatively even distribution for the four limb segments. It demonstrates that under modern conditions trauma strikes all parts of the body indiscriminately, in this respect differing from all other pathologic conditions which may cause amputation. The fact that the figure for amputations of the lower leg is slightly larger than for the other parts is to be explained by the greater readiness

- Feb 18 The animal recovered completely from anesthetic. There was no evidence of tetany. She took little food. The bandage was removed.
- Feb 24 The blood calcium was 8.2 mg per hundred cubic centimeters of serum. Her general health was good.
- March 3 The animal was in good health. The injured leg was not put to the floor when walking. The blood calcium was 9 mg per hundred cubic centimeters of serum.



FIG 3—Stage in the healing of a fracture in a normal cat ten days after the break. *A* indicates new formation, *B*, cartilage, and *C*, connective tissue which runs from the surface of one fragment to the other.

- March 8 There was not any evidence of union as tested by handling. A roentgenogram did not show any callus formation.

The animal was killed on this date. Enclosing the fractured ends was a tough fibrous capsule-like structure, which offered no gritty resistance to a scalpel. This capsule, while preventing separation of the ends one from another, when the two fragments (after removal of the muscles) were pulled apart, nevertheless, allowed of considerable angulation of the two pieces in any direction whatsoever.

myelitis, either acute or chronic, acute purulent arthritis of the knee or ankle, or to acute infections following traumatic injury. Four followed compound fractures. The amputations were performed for the purpose of saving the life of patients desperately ill or to get rid of a chronically infected part which, from the functional standpoint, was useless and in which there was no outlook for future improvement.

The much greater frequency of the amputations of the lower limb is accounted for partly by the higher incidence of such infections in the leg and by their greater severity here, and partly by the fact that the functional results of amputation of the leg are so much better than those of the arm. In the case of the arm, regardless of how great the crippling, so long as the part is retained, the result will be better than if an amputation is performed. This is not true in the case of the lower extremity, and it is often preferable to sacrifice a portion of a limb than to save it at the expense of prolonged treatment when there is every

TABLE 27—*End-Results of Amputations for Pyogenic Infection*

Number of cases of primary amputations			55
Died in hospital following amputation		6 or 17%	
Septicemia		4	
Uremia		1	
Shock		1	
Died since leaving hospital		0	
Alive and apparently well		22 or 60%	
Have had reamputations	7 or 20%		
Using artificial appliances		16 or 47%	
Painful stump		1 or 3%	
Incapacitated because of age or physical condition		5 or 14%	
Not located		7 or 20%	

indication that it will at the best be permanently damaged. When dealing with infections of the upper extremity the surgeon does not have the option of sacrificing the limb except when death is likely to occur, whereas in infections of the lower limb the option of amputation is always present, and the surgeon must take into consideration not only the risk to life, but also the future functional value of the limb, the probable duration of the illness, the chances of future trouble and the social and economic status of the patient.

Fourteen or 38.8 per cent of the amputations were performed by the open or flapless method, the remainder were closed by suture. The open type of amputation was used in all cases of acute or severe infection. The closed method was used only in subacute or chronic cases and when the level of amputation was well removed from the seat of the infection.

**Results.** There were six deaths, four from septicemia following amputation of the thigh, one from uremia following amputation below the knee, and one from shock following disarticulation of the hip, a total mortality rate of 17 per cent. Of the twenty-nine patients with primary

*Cat C*—Feb 17, 1926 An adult female cat was used as the control for cat A and B, series II The left radius and ulna were fractured A starch bandage was applied

Feb 19 The bandage was removed The animal was apparently not suffering any ill effects

Feb 24 No attempt had been made as yet to bear weight on the fractured leg

March 3 The leg was put to the ground, but little weight bearing was attempted Manipulation revealed some degree of union A roentgenogram showed a slight amount of callus



Fig 5—Section of the membrane uniting a fracture in a normal cat twenty-three days following the break A indicates new bone, and B, cartilage Compare this figure with figure 6

March 8 Union was firm and a roentgenogram showed definite callus deposition

SERIES III—*Cat A*—March 28, 1926 An adult female cat with a blood calcium of 10.8 mg per hundred cubic centimeters of serum was used Thyroparathyroidectomy of left side and external parathyroidectomy of the right side was performed The left radius and ulna were fractured A starch bandage was applied

March 25 There was not any evidence of tetany The animal took food freely

March 30 The broken leg was held off the floor Praeternatural mobility was present The blood calcium was 8.7 mg per hundred cubic centimeters of serum

if this is insufficient, to amputate at a still higher level. There is also a possibility that tourniquet pressure may actually be harmful.

From a knowledge of the after-history of these cases one is convinced of the futility of amputation as a method of treatment unless it is followed by a prolonged period of after-treatment to improve the circulation of the remaining limb. Limitation of activity and physiotherapy in various forms are the principal therapeutic measures and it would appear necessary to make some provision for the care of these patients with chronic cases in a special institution if improvement in the results is to be obtained.

*Tuberculosis*—In the group of 420 amputations, there were thirty-seven, or 8.8 per cent, due to tuberculous infection. All were primary.

TABLE 28—*End-Results in Endarteritis and Thrombo-Angiitis*

Number of cases of primary amputations		27
Died in hospital following amputation		4 or 14.7%
Cerebral thrombosis	1	
Septicemia	1	
Cause unknown	2	
Died since leaving hospital 'heart trouble' (2 years postoperative)		1 or 3.7%
Alive and reporting		16 or 59.2%
Wearing appliance and able to work	9	
Totally disabled	7	
Not located		6 or 22%

TABLE 29—*Tuberculous Lesions Necessitating Amputation*

Situation	No. of Cases	Percentage
Tuberculous infection of the foot or ankle	19	54.4
Tuberculous arthritis of the knee	8	21.6
Tuberculous infection of the hand, wrist and tendon sheaths	5	13.5
Tuberculous arthritis of the elbow	2	5.4
Tuberculous coxitis	2	5.4

amputations. Of these twenty-eight, or 75.7 per cent, were amputations of the lower extremity and nine or 24.3 per cent, were of the upper. The proportion of amputations of the upper extremity was higher in tuberculosis than in any other disease group with the exception of the traumatic group.

All of the patients were adults. The ages varied from 18 to 60 years and the average for the group was 36 years.

The location of the lesions necessitating the amputations is shown in table 29.

The list, however, fails to give any idea of the actual situation and why amputation was resorted to instead of conservative treatment. Excluding the tuberculous lesions of the tarsus and ankle, amputation for tuberculous disease of the joint has been performed at the Massachusetts General Hospital only in exceptional cases. These were usually chronic cases with a duration of many years and in which for one



March 25 The bandage was removed

April 10 The animal put its foot to the ground without hesitating, union appeared to be firm

May 11 There was a definite deposition of callus at the site of the fracture, the animal moved about easily and without inconvenience The blood calcium was determined on three different occasions and was never below 10 mg per hundred cubic centimeters of serum

SERIES IV—*Cat A*—March 11, 1927 An adult female cat with a blood calcium of 117 mg per hundred cubic centimeters of serum was used Both parathyroids were removed from the left side One parathyroid was removed from the right side The left radius and ulna were fractured A plaster bandage was applied

March 12 The animal had not entirely recovered from the anesthetic

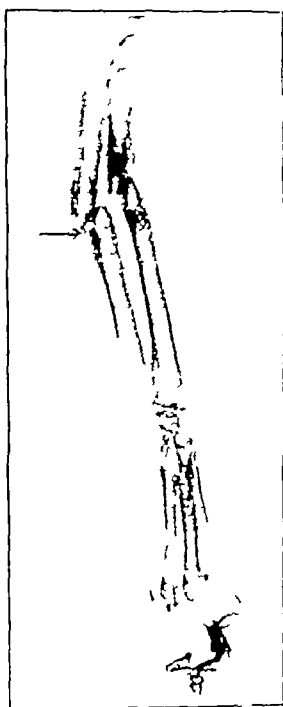


Figure 7

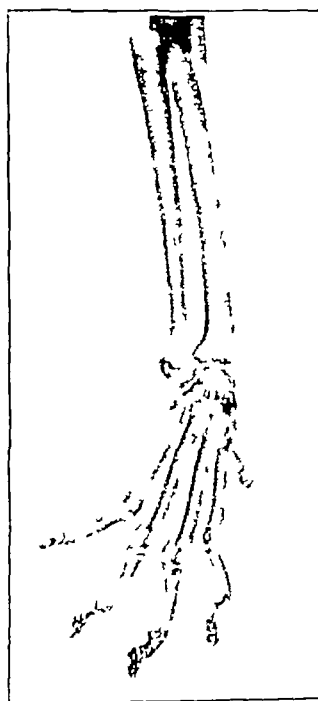


Figure 8

Fig 7 (series I, cat A)—Twenty-one days after fracture The arrow indicates callus

Fig 8 (series I, cat B)—Twenty-one days after fracture

March 13 The bandage was removed The animal recovered from anesthesia There was not any evidence of tetany She took food and did not attempt to apply the broken leg to the floor

March 14 The blood calcium was 83 mg per hundred cubic centimeters of serum The animal appeared to be in good health and moved about the cage on three legs

March 17 The blood calcium was 84 mg per hundred cubic centimeters of serum There was not any evidence of tetany The general health of the cat appeared to be excellent

The mortality from tuberculosis has been appalling. The date of death is known in fourteen of the sixteen patients who died and in eleven the fatality occurred within fifteen months after the operation. This suggests that the death had some relation to the operation. On investigation we find that only eight of the thirty-seven patients or 21.6 per cent, received treatment in a sanatorium after operation and it is probable that general antituberculous treatment was not carried out as thoroughly as it should have been because it was thought that the focus of disease had been removed. The high mortality figures serve to emphasize the fact that tuberculosis must always be treated as a generalized disease regardless of how localized may be its manifestation. General antituberculous measures must be enforced just as much after amputation as if conservative treatment is being used. On the basis of this study of end-results the claim that amputation offers a short road to a complete cure cannot be sustained.

TABLE 30—*End-Results of Amputations for Tuberculosis*

Number of amputations		27
Died in hospital following amputation	2 or 7.4%	
Septicemia	1	
Pulmonary tuberculosis	1	
Died since leaving the hospital	14 or 52%	
Pulmonary tuberculosis	7	
Tuberculous enteritis	2	
Tuberculous meningitis	1	
Tuberculosis of kidney and bladder	1	
Abscess of cervical lymph nodes	1	
Cerebral hemorrhage	1	
Unknown	1	
Alive but suffering from active tuberculous process elsewhere in body	5 or 18.5%	
Alive and apparently well	12 or 44%	
Not located	2 or 7%	

*Diabetic Gangrene*—There were thirty-six cases of amputation for diabetic gangrene representing 8.5 per cent of the entire series. Twenty-eight of these were primary amputations and eight reamputations. All of the primary amputations were necessitated by actual gangrene with the exception of one case of persistent ulceration and one in which sepsis was the chief factor. Diabetic gangrene rarely involves the arm and all of our cases were amputations of the lower extremity—of the thigh twenty-one and of the lower leg fifteen. That diabetic gangrene is usually a disease of old age is borne out by the age incidence of the group the average being 57.4 years. That there are exceptions to the rule is shown by the fact that the ages varied from 26 to 78 years.

The surgical hazard in these cases is great because of the usually poor physical condition of the patient, the result of the frequent combination of arteriosclerosis, diabetes and sepsis. There were twelve deaths in the hospital, a postoperative mortality of 33 per cent. Reamputation was required in eight cases or 22 per cent. In five cases the sepsis spread to a distant focus of the gangrenous process and was gangrenous in nature.

May 2 This animal is still alive and now has firm bony union, as tested by handling

*Cat B*—March 11, 1927 An adult female cat with a blood calcium of 11 mg per hundred cubic centimeters of serum was used Both external and internal parathyroid were removed from the right side, together with half of the upper third of the right thyroid The left radius and ulna were fractured A starch bandage was applied

March 12 The animal had not completely recovered from the anesthesia

March 13 There was not any evidence of tetany The bandage was removed The animal took food

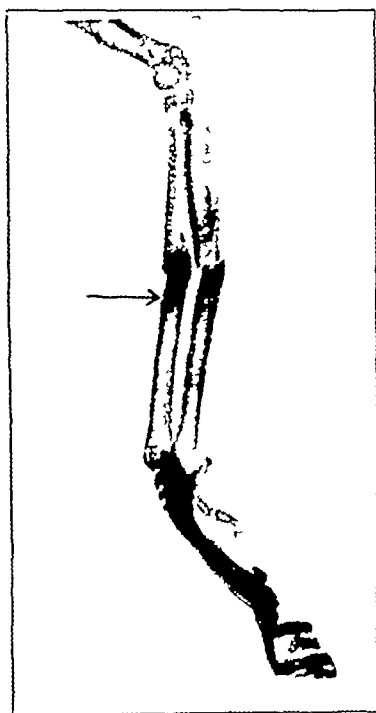


Figure 11

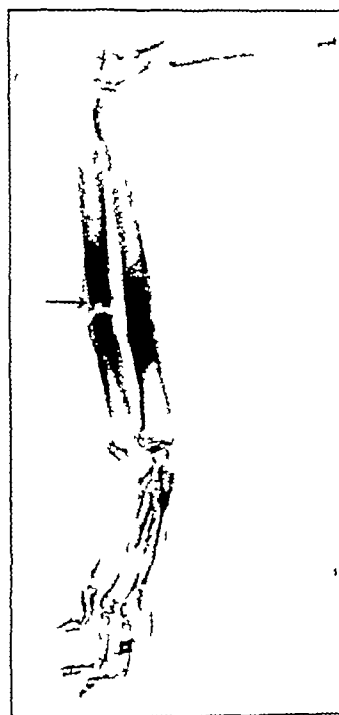


Figure 12

Fig 11 (series II, cat B) —Nineteen days after fracture The arrow indicates callus

Fig 12 (series II, cat C) —Nineteen days after fracture The arrow indicates callus

March 14 The general health was good The blood calcium was 10.8 mg per hundred cubic centimeters of serum The animal did not apply the broken leg to the ground

March 17 The cat had not as yet put the injured leg to the ground in walking

March 22 She put her weight on the broken leg A certain amount of thickening at the site of fracture was perceptible. Angulation of fragments occurred if lateral pressure was applied

Most of the risk of operation in diabetic patients has been removed by the discovery of insulin. The cooperation of an internist is of invaluable assistance, and medical supervision should go hand in hand with the surgical care. With skilful medical treatment, the surgeon may now disregard the diabetic factor as far as the operation is concerned.

Insulin came into use in 1923, and we have been interested to analyze the end-results in our cases of diabetic gangrene with reference to this date. Actually, the figures are disappointing, as the death rate appears to be about the same before and after the use of insulin, but we are convinced that in a larger group of cases the results would be different.

In the group of thirty-six amputations there were twelve deaths in the hospital, and eleven patients have died since discharge from the hospital. These are divided as shown in table 32.

The end-results are known in only twenty-seven of the thirty-six cases (table 31), but it is certainly a striking fact that of this number only four patients are alive and only two are able to report themselves in

TABLE 32—Deaths Before and After the Use of Insulin

	Before Insulin Therapy	Since use of Insulin
Number of amputations	30	12
Hospital deaths	7	6*
Deaths since discharge	6	2*
Total deaths	13 or 65.4%	8 or 67%

\* Amputated before insulin, but have died since.

good health. Diabetic gangrene would appear to be of ominous portent even for those who survive the operation.

*Arteriosclerotic Gangrene*—Amputations for arteriosclerotic gangrene, excluding the diabetic cases, numbered thirty-six and constituted 8.5 per cent of the entire series. Of these, thirty-two were primary amputations and the remainder reamputations. Most of the patients were of advanced age, the average for the group being 69.3 years. The youngest patient was a man aged 32, the diagnosis was based on the pathologic examination of the amputated specimen which showed precocious arteriosclerosis. The oldest patient was aged 88. The post-operative hospital mortality was 22.2 per cent which is in keeping with the poor surgical risk which these cases represent.

Arteriosclerotic gangrene occurs almost exclusively in the lower extremity, and amputations of the lower limb were performed in all of our cases. In this condition, there is practically no alternative to amputation above the knee. In twenty-nine of our cases, or 80 per cent, amputations of the thigh were performed and there were only seven in which amputations of the lower leg was employed. Three of the latter required reamputation because of extension of the gangrene to the

*Cat 101*—March 8 An adult cat, with a blood calcium of 11 mg per hundred cubic centimeters of serum was used Both parathyroids were removed from the right side and one parathyroid was removed from the left side The left radius and ulna were fractured A plaster bandage was applied

March 9 The animal had not completely recovered from the anesthetic The blood calcium was 98 mg per hundred cubic centimeters of serum

March 10 The animal completely recovered from the anesthesia There was no tetany She took food

March 17 The cat walked on three legs There was no evidence of bony union, as tested by handling The blood calcium was 9 mg per hundred cubic centimeters of serum

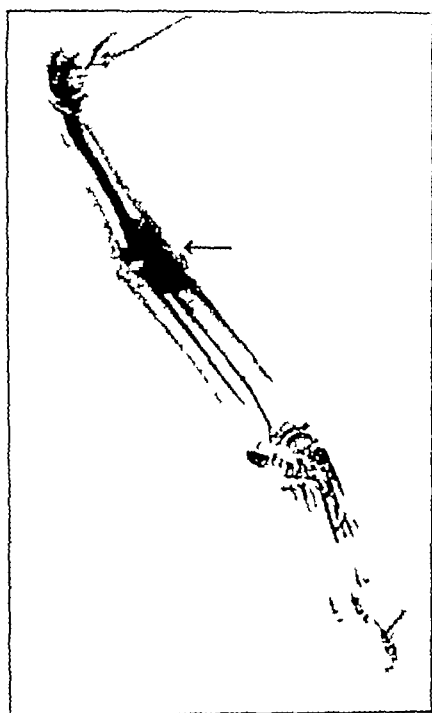


Figure 15

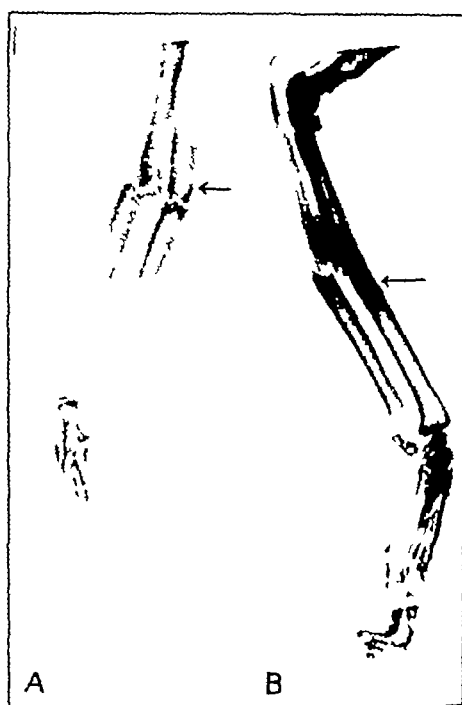


Figure 16

Fig 15 (series III, cat C) —Forty-nine days after fracture

Fig 16 (series IV, cat A and B) —*A* shows cat C twenty days after fracture The arrow indicates a callus *B* shows cat B twenty days after fracture The arrow indicates a suggestion of callus

March 22 The general health was excellent The animal did not put her foot to the floor when walking

March 25 Pressure applied to the lower fragment produced angulation at the site of the fracture

March 31 The animal did not attempt to apply her injured leg to the floor when walking She was killed on this date

Gross examination of the fracture showed that there was a tough membrane encircling both ends of the fragments, and while this mem-



roentgen-ray examination) until the fifth or sixth week. Further, the age of the animal did not have any apparent effect on the time required for the deposition of callus. The formation of callus appears to depend largely on the amount of the blood calcium. The blood calcium was reduced in these animals by from 2 to 3 mg per hundred cubic centimeters of serum, and remained at the reduced levels for from four to five weeks. With the return to normal blood calcium there was abundant deposition of callus, and union occurred in the usual manner.

In cases in which only two parathyroids were removed there was not any decrease in the blood calcium value and consequently no delay in bony union.

Complete immobilization of the fractures was not maintained for more than forty-eight hours, yet callus appeared within from fifteen to sixteen days in the normal animals, and union was apparently firm inside of twenty-one days. The alignment of the fragments, as shown by the roentgenograms, was excellent. This would seem to indicate that a certain amount of mobility of the fragments is not at all a hindrance to the formation of callus, and with the care of the injured leg left to the devices of the animal, apposition is maintained.

In the first five to six days following a fracture in a normal animal one sees an invasion of the blood-clot formed at the site of the fracture by fibrous connective tissue. By the tenth to eleventh day the blood-clot has either entirely or almost entirely disappeared and has been replaced by connective tissue, with probably a small amount of cartilage and here and there small areas of new bone. This invasion of the blood-clot by connective tissue and the formation of cartilage occur in cats in which three parathyroids have been removed. The process of repair, however, from then on is delayed, as is shown by the microscopic section of the membrane which is laid down at the site of the fracture in cat 101. Here are seen well organized connective tissue, many new blood-vessels, and small areas of cartilage. This corresponds closely with the picture in a normal animal at about the tenth or twelfth day, with the exception that in the latter new bone formation is generally visible, and callus can be made out by roentgen-ray examination by the fourteenth day. If cat 101 had been allowed to live the blood calcium would have returned to normal about the fourth or fifth week following the fracture, calcium salts would then have been deposited in the connective tissue at the site of the fracture, and union would have occurred in the usual manner.

#### CONCLUSIONS

- 1 The removal of two parathyroids does not delay the union of fractures.

- 2 The removal of three parathyroids delays bony union for as long as from four to five weeks.

basis, and in all cases of embolism there was an associated diagnosis of arteriosclerotic heart disease, and this, presumably, was the source of the thrombus. One case of thrombosis occurred during convalescence from pneumonia. Embolectomy was performed in one case of sudden obstruction of the brachial artery but was unsuccessful in reestablishing the circulation, and amputation was necessitated later. Gangrene was present in several instances, and it is difficult to differentiate these cases from arteriosclerotic gangrene. Most of the amputations were of the lower leg, being distributed as follows: thigh, seven; lower leg, two; and upper arm, one.

There were two deaths in the hospital, one from cardiac failure and the other from bronchopneumonia (table 37). Three patients have died since discharge from the hospital, one from cerebral hemorrhage and two from cardiac lesions. Of the other four patients, three are alive and well, and one has not been located. Two of the survivors show good functional results and are working, the third has suffered total disability.

TABLE 37—End-Results of Amputations for Thrombosis and Embolism

Number of cases (10 amputations)		
Died in hospital		2 or 20%
Cardiac failure	1	
Bronchopneumonia	1	
Died since leaving hospital		3 or 30%
Myocardial failure (3 weeks postoperative)	1	
Cerebral hemorrhage (1 year postoperative)	1	
Valvular heart disease (6 years postoperative)	1	
Alive and apparently well		5 or 50%
Not located		1 or 10%

*Miscellaneous*—Gas Bacillus Infection. (Eight cases; eight amputations, 19 per cent.) All but one of the cases of gas bacillus infection developed following traumatic injury, five were compound fractures; one was a case of traumatic amputation and one was an injury of a soft part. The striking fact about these cases is that in every one the risk of closing the wound by primary suture had been taken. The infection manifested itself in from three to fourteen days. The remaining case was that of a feeble-minded child with an ulcerated foot due to syringomyelia. There was no history of injury and the infection developed spontaneously, probably from lack of proper care of the wound. The open type of amputation was performed in each instance. Three cases terminated fatally, or 37 per cent.

*Ununited Fractures*. (Four cases; four amputations, 0.9 per cent.) Amputation was performed in cases of ununited fracture only when some pathologic process was present which prevented union. The patients were of such advanced age that a nonunion of the fracture was as necessary. In one case there was a fracture of the distal



# END-RESULT IN THIERSCH GRAFT

A CASE OBSERVED AFTER THIRTY YEARS \*

GEORGE A WILLIAMS, M D

ATLANTA, GA

Since skin grafting, a heritage from antiquity,<sup>1</sup> was placed on a firm scientific basis by Reverdin<sup>2</sup> and later by Thiersch<sup>3</sup> and by Ollier,<sup>4</sup> numerous observations have been made on the phenomena involved in its successful conclusion. Davis and Traut<sup>5</sup> have recently summarized and continued the work begun by Garre,<sup>6</sup> in which the processes of vascularization and innervation of the transplanted tissue have been quite definitely determined. Most of these studies were performed on laboratory animals after varying periods of time, up to two years, had elapsed since grafting. The purpose of this article is not to deal with the physiologic changes involved in transplantation, but to discuss the end-result obtained. This, to be ideal, must closely approach the normal uninjured skin in appearance and function. An opportunity for such a study was presented by a patient who had been operated on thirty years previously by Dr J L Campbell.

## REPORT OF A CASE

J W, a mulatto laundress, aged 20, was treated at the Grady Hospital in 1897 for a varicose ulcer of the left leg. The affected veins were ligated and resected, and the ulcer bed was covered with Thiersch grafts. Convalescence was uneventful, and two months later she resumed her occupation. There was no recurrence of the ulcer, but the foot would occasionally swell slightly after she had been standing for long periods of time. For the past few years this had been more troublesome, but it had only occasionally necessitated the use of an elastic stocking. In April, 1927, nearly thirty years after the grafts were applied, the patient was readmitted to the hospital, she was found to be suffering from a squamous cell carcinoma of the urethra.

At this time, an examination of the leg revealed several small scars over the courses of the greater and lesser saphenous veins and a lightly pigmented area

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\* From the Emory University School of Medicine Division of Grady Hospital

1 Baas. History of Medicine, New York, 1889, p 46. Davis. Plastic Surgery, ed 1, Philadelphia, P Blakiston's Son & Company, 1919, vol 1, p 3. Garrison. History of Medicine, ed 3, Philadelphia, W B Saunders Company, 1924, p 64.

2 Reverdin. Bull de la Soc de Imp Chir, 1869, p 493.

3 Thiersch. Verhandl d deutsch Gesellsch f Chir 3 69, 1874.

4 Ollier. Bull Acad de med, Paris 1872, 2s, p 244.

5 Davis and Traut. Ann Surg 82 871, 1925.

6 Garre, quoted by Davis and Traut. Beitr zur klin Chir 4 625, 1889.



## COMMENT

The normal skin (fig 2 *C*) showed the usual histologic structure, which needs no description here, but which is useful in a comparative study of the other sections

The section of transplanted skin (fig 2 *A*) showed many variations from the normal. There was an excessive conification, the diameter of which equaled that of the stratum mucosum. The intervening stratum lucidum and stratum granulosum were sharply defined. The diameter of the stratum mucosum was much less than that of normal skin, largely owing to the fact that the stratum germinativum was smooth and straight instead of dipping in between the papillae of the corium. The individual cells of the germinal layer stained deeply and were closely spaced. There were no hair follicles, and only rarely a group of cells occurred which

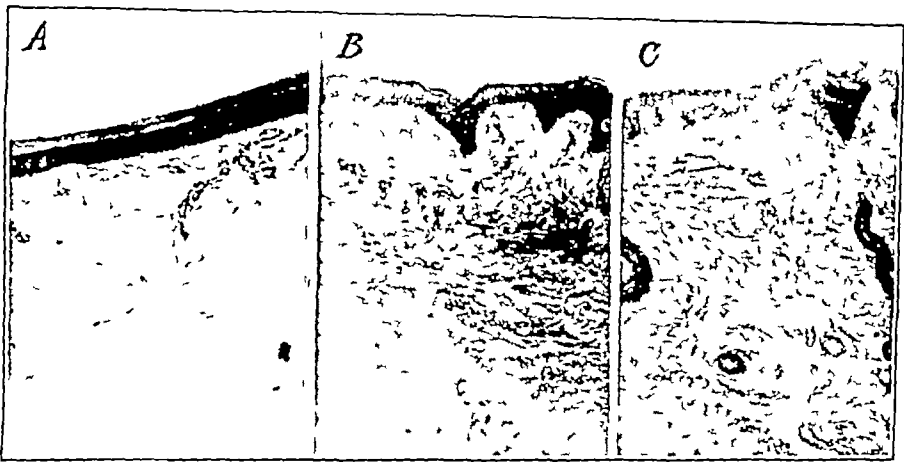


Fig 2—Histologic appearance of sections of *A*, Thiersch graft, *B*, area from which the graft was taken, *C*, normal skin of the opposite leg

suggested the atrophic remains of a glandular structure. The amount of connective tissue was excessive and almost completely replaced the other components of the corium.

The section of skin removed from the area from which the graft was taken (fig 2 *B*) revealed a structure which in some ways suggested an intermediate state between the normal skin, on one hand, and the grafted skin, on the other. The stratum corneum, while not so pronounced as in the graft, was definitely thicker than is usually found in this region. The stratum germinativum was not smooth and straight, but it did not dip as deeply into the corium as in the normal skin. Well developed hair follicles and glands were found, but there were also atrophic structures which undoubtedly represented such organs injured as the graft was excised at operation.

When the structure of the Thiersch graft is considered, some of these observations can readily be explained. As only the tops of the

accounted for fifty, or 61 per cent, of the eight Griggs amputations of the upper extremity performed for all causes.

Most of the amputations for sepsis were performed on the lower limb.

In amputations for thrombo angitis obliterans, in other words, the results were unsatisfactory chiefly because of progression of the disease, involvement of other limbs and the necessity of repeated amputations.

In amputations for tuberculosis, a large number of the patients died of tuberculous complications within two years of amputation. This was apparently due to the fact that general antituberculous measures were not carried out after the operation.

When amputation was performed for diabetic gangrene only a few of the patients survived for more than a few years.

In both diabetic and arteriosclerotic gangrene the best functional results were obtained with the Griggs-Stokes amputations.

Eighty-eight patients on whom amputation was performed for carcinoma have remained well for a number of years indicating that the prognosis after amputation is better than has been generally thought.

# THE HEALING OF FRACTURES

## AN EXPERIMENTAL STUDY \*

LEONARD W ELY, M D

SAN FRANCISCO

Some years ago I published the results of an experimental study on the healing of fractures in cats<sup>1</sup>. Three sets of experiments were performed: simple fractures, incision of the periosteum with instrumental division of the bone, and circular division of the periosteum with instrumental division of the bone. As a result of this work I came to the following conclusions:

- 1 When the periosteum is intact, bony union is to be expected.
- 2 When the periosteum is completely divided, bony union is not to be expected.
- 3 When the periosteum is slit, bony union may or may not take place.

After an ordinary fracture, hemorrhage takes place from the marrow canal under the periosteum. The periosteum is stripped up from the cortex by this hemorrhage and by the fracture itself. Then come the deposition of fibrin, the formation of granulation tissue and the formation of cartilage and fibrocartilage in the space beneath the stripped up periosteum. Probably the function of the periosteum is important only in the early stages, up to the formation of the cartilaginous callus. The periosteum probably serves to keep the hemorrhage from escaping and the granulation tissue undisturbed. It has no bone-forming function, and bone is not built of it. The subsequent ossification of the cartilaginous callus is carried out almost entirely, if not exclusively, from the external aspect of the cortex. The internal callus does not play an effective part in the union. It is rudimentary when it is present.

The present study was undertaken in order to investigate farther the rôle of the periosteum in the healing of fractures. I proposed to remove the periosteum circularly from an appreciable length of bone, and then to fracture the bone. If after this was done, union took place, the so-called bone-forming function of the periosteum could be discounted. I found that such an operation is extremely difficult, if not actually impossible. In some operations I removed as much of the periosteum as possible from about 1.5 cm. of the humerus, before fracture; in others, I contented myself with simply stripping the periosteum from about 7 mm. of the end of each fragment.

The wound was then closed and a collodion dressing was applied. Cats were chosen for the experiment and the operations were performed under complete ether narcosis, and with asepsis. I operated on ten cats. Five of these died within a few days and are omitted from

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\* From the Laboratory of Surgical Research, Stanford University.

1 Ely, Leonard W. Arch. Surg. 5:527 (Nov.) 1922.

## EXPERIMENTAL WORK

Cats were chosen for the experiments. There are four parathyroids in these animals, two internal and two external. The internal lie buried in the thyroid, one in each lobe and are situated near the upper pole. The external lie on the outer surface of the thyroid near the upper border; their exact situation, however, may vary. They are small bean-shaped bodies somewhat paler than the thyroid and are about 7 mm. long by 4 mm. broad.

All operations were aseptically performed under sodium 3-aminocetyl barbituric acid anesthesia (0.5 cc. per kilogram of body weight administered intraperitoneally).

An incision was made beginning half an inch above the thyroid cartilage and extending down over the trachea for about 3 inches (7.6 cm.). In this manner the ribbon muscles of the neck were exposed. These were retracted, thus bringing the trachea into the field of operation. The thyroid lobes could then be delivered at the surface of the wound and as many parathyroids as required extirpated. After tying off all bleeding points, the thyroid was allowed to fall back into the normal position. The retracted muscle were brought together and held by catgut sutures, and the skin was closed by black silk; a collodion dressing then being applied. By means of a small Thomas wrench a simple fracture was then produced in the left radius and ulna and the leg put up in a starch bandage for forty-eight hours, or until the animal had completely recovered from the anesthesia.

Blood calcium determinations by the Eisdall-Kramer method were made previous to the operation and at various periods subsequently.

In this manner about thirty cats of various ages were operated on in series of threes; one, the control, was simply subjected to a fracture of the left radius and ulna; another had two parathyroids removed either from the same side or one from each side; while the third had three parathyroids extirpated. Removal of an internal parathyroid always necessitated excision of some of the thyroid tissue along with it. In some instances the whole thyroid lobe together with its two parathyroids was extirpated.

By making successive microscopic sections of the tissues removed at operation one obtained a check on the number of parathyroid glands excised. When the animals were killed a further careful examination of the remaining thyroid tissue was made in order to be sure of the number of parathyroids extirpated.

## EXPERIMENTS

**SERIES I—Cat 1—Jan 15, 1926** Right thyroparathyroidectomy was performed on a young female cat; two parathyroids were identified in the tissue removed. The left radius and ulna were fractured in the middle third. A starch bandage was applied and a roentgenogram taken.

Jan 17 The bandage was removed. The animal took its food well and did not show any evidence of tetany. Between January 17 and January 27 the animal remained normal but refused to put its weight on the left leg. On the latter date there appeared to be slight mobility at the site of the fracture, as tested by handling although the leg was used to some extent in walking.

Jan 29 A roentgenogram showed trace of callus at the site of fracture. The animal bore its weight on the injured limb. There was little, if any, praeternatural mobility on handling.

bias The marrow canal of the other fragment was continuous with the marrow in the new callus, and the dividing line between them was difficult to make out. The extreme end of the cortex of the closed fragment was irregular in its contour, with indentations like Howship's lacunae. Dead bone could not be seen.

*Result of Experiment*—Bony union occurred 119 days after the fracture, with removal of little periosteum, but with stripping of the periosteum from about 7 mm of the end of each fragment.

CAT 48—Duration of experiment, thirty-three days.

*Operation*—The incision was made between the triceps and the deltoid. The periosteum was separated from about 7 mm of the end of each fragment, but little of it was removed.

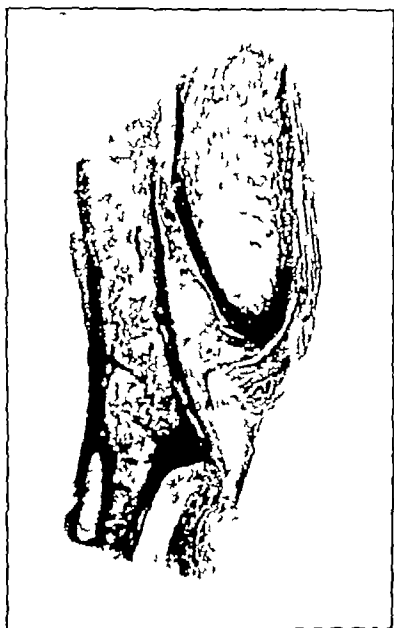


Figure 1



Figure 2

Fig 1 (cat 46)—Photograph of the stained slide. Note the mass of cartilaginous callus and fibrocartilaginous callus between the two adjacent cortices. One of the fragments is caught on the bias, the other is caught square.

Fig 2 (cat 46)—Photograph of another slide showing the other fragment caught square by the knife. It is likely that this experiment would have ended in bony union.

When the cat died from an unknown cause there were no signs of infection. Overriding of the fragments was present, but apparently union had begun, for motion was restricted at the site of the break.

*Microscopic Examination*—Both fragments were caught by the knife on the bias, and the ends of the marrow canals were therefore shut off by the cortex. In the marrow canal of each fragment new bone trabeculae had been developed apparently from fibrous tissue, but there was no evidence that this new bone was

Feb 10 The preternatural mobility not so marked as previously and the animal put her foot to the floor of the cage, although she bore little weight on it. The blood calcium was now 10.2 mg per hundred cubic centimeters of serum.

Feb 24 The blood calcium was 10.4 mg per hundred cubic centimeters of serum. The animal bore weight on her leg. There was slight limp. On palpation there was apparent evidence of callus formation. This was confirmed by a roentgenogram.

March 1 The animal bore her weight on the injured leg, and walked with a scarcely perceptible limp. On this date she was killed. Microscopic examination of the remaining thyroid showed the presence of the single internal parathyroid embedded in the thyroid tissue.

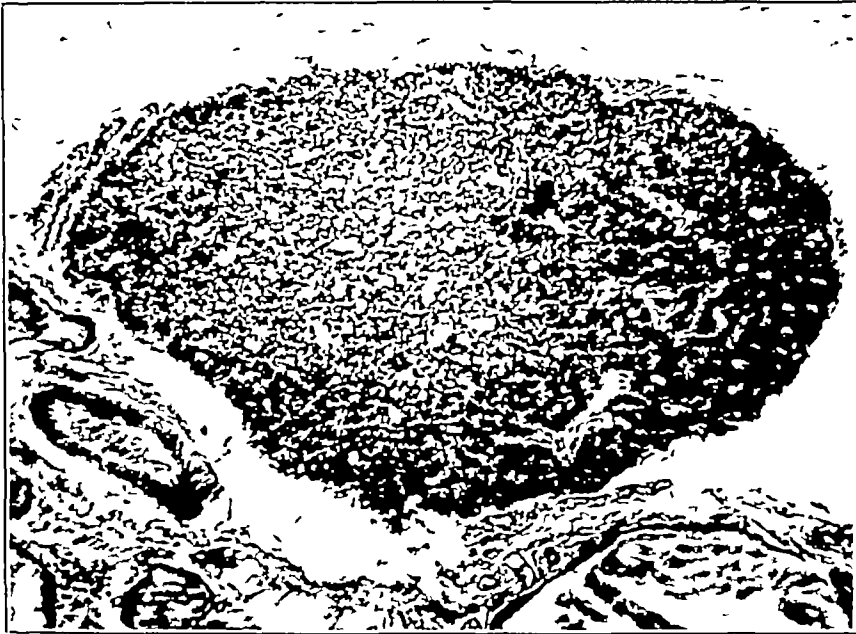


Fig 2—Internal parathyroid with thyroid in a cat

*Cat C*—Jan 15, 1926 A young female cat was used for a control for cat *A* and *B*, series I. The left radius and ulna were fractured. A starch bandage was applied.

Jan 17 The bandage was removed. The rate of healing of the fracture in this case was similar to that described in cat *A* of this series. The first slight indication of callus by a roentgenogram was on January 9.

Feb 5 Definite evidence of callus was found. The foot was applied to the floor of the cage without any hesitation and there is no noticeable limp.

SERIES II—*Cat A*—Feb 17, 1926 An adult female cat was used with a blood calcium 10.5 mg per hundred cubic centimeters of serum.

Left external parathyroidectomy and right thyroparathyroidectomy was performed, i. e., three parathyroids were removed. The left radius and ulna were fractured. A starch bandage was applied.



playing an active part in the process of healing. In one fragment the cortex was being broken up as if for rearrangement of its structure. The two fragments overlapped 1.5 cm and their cortices were not contiguous. There was a space of almost 1 cm between them which was bounded on two sides by bone and on two sides by irregular bundles of fibrous tissue. It was almost filled by two masses of cartilage, one on each cortex, and between these two masses of cartilage there was a distinct space like a joint cavity. It appeared as if the cartilage were being formed from fibrous tissue, for fibrous tissue still ran in between the two masses and shaded into their structure. Ossification of this cartilaginous callus had begun from the cortex. There was no evidence of any bony bridge in the periosteum, nor, in fact, did any distinct periosteum stretch across the gap between the two fragments. The entire cortex was alive. There was no dead bone anywhere.

*Result of Experiment*—A fairly stable false joint was found thirty-three days after fracture, with separation of the periosteum from the cortex of each fragment for a distance of 7 mm. A free production of cartilaginous and bony callus had



Fig 5 (cat 48)—Roentgenogram of the specimen

been made on each fragment, but these were separated by what had every appearance of being a joint.

CAT 50—Duration of experiment, twenty-five days.

*Operation*—The periosteum was removed where it could be easily reached. The bone was divided, and the periosteum was separated from each fragment for a distance of about 7 mm from its end. The wound healed by first intention. When the cat died the fragments of the humerus moved freely on each other, with marked overriding.

*Microscopic Examination*—The fragments overlapped to the extent of about 1.5 cm, and there was a space between them of about 6 mm. The cat was young, as the epiphyseal cartilage disk was still present. The open marrow canal of one fragment was plugged with fibrin showing areas of calcification in its meshes. This fibrin was fairly sharply defined from the marrow tissue, but in some places shaded into the fibrous tissue of the marrow. The open end of the other fragment was plugged with fibrous tissue. The divided ends of the cortex had been very much splintered, and besides this, they were being opened longitudinally in slits. Blood vessels could be seen in some of these slits. There was no evidence

*Cat B*—Feb 17, 1926 An adult female cat was used with a blood calcium of 10 mg per hundred cubic centimeters of serum One external parathyroid was removed from each side The left radius and ulna were fractured A starch bandage was applied

Feb 19 The cat took food The fractured leg was held off the floor There was not any evidence of tetany The bandage was removed

Feb 24 The blood calcium was 9.9 mg per hundred cubic centimeters of serum



Fig 4—Stage in the healing of a fracture in a young cat sixteen days after the break A indicates new bone, B, connective tissue, and C, fibro-cartilage

March 3 There appeared to be some attempt at union, as tested by handling The injured leg, although put to the ground, was not used for any perceptible amount of weight bearing The blood calcium was 10.2 mg per hundred cubic centimeters of serum

March 8 On manipulation there appeared to be firm union at the site of fracture and the animal bore weight on all four legs A roentgenogram showed definite deposition of callus at the site of fracture The animal was killed for examination

surface of the fibrous tissue bordering on these slits had much the appearance of a synovial membrane. In the open spaces were collections of fibrin. The whole appearance of the tissues was that of a forming joint. It was improbable that union ever would take place, no matter how long the animal had lived.

*Result of Experiment*—Twenty-five days after fracture, with removal of some periosteum from the end of the fragments, and with a denudation of the cortex for 7 mm, a new joint was evidently forming.

CAT 52—Duration of experiment, seventy-six days

*Operation*—An incision was made between the deltoid and triceps as in the other operations. Great care was taken to remove as much of the periosteum as possible from about 1 cm of the shaft of the humerus, and little of the periosteum was stripped back. When the cat died, union had apparently taken place with much overriding.

*Microscopic Examination*—The stained slide did not show nearly as much overriding as appeared in the gross specimen. The end of one fragment had been caught on the bias by the knife so that the cortex closed it. The end of



Fig 8 (cat 52)—Roentgenogram of the specimen

the other fragment had been caught square. The two fragments were firmly united by bone, and the catching of one fragment on the bias enabled one to see very well the extent of the bony callus. New bone trabeculae in the shape of fairly loose-meshed spongy bone had formed in the open end of one fragment, partially blocking it, and these were separated from the rest of the bony callus by a mass of fibrous tissue, fibrocartilage and hyaline cartilage, which was evidently undergoing ossification, with new bone trabeculae springing from the cortex of the closed fragment. In fact, the most active bone formation appeared to be taking place from the outside of the cortex. Across most of one side of the callus the periosteum could be traced, and underneath it and springing from the closed cortex of the fragment a new cortex was forming for about one-half the distance across the gap. The other side of the callus was irregular, and a continuous periosteum could not be traced across it. New bone production was, as usual, free in the angle where the periosteum leaves the bone. On the outside of the far cortex of the open fragment, the periosteum had not re-formed at the end of the bone from which it was stripped at the time of the operation, but at a considerable distance from the fractured end of the bone a strip of new trabeculae

April 10 There was no clinical evidence of union of fracture, otherwise the cat appeared normal

April 20 There was still no evidence of union

April 30 The blood calcium was 10.2 mg per hundred cubic centimeters of serum Manipulation revealed evidence of slight bony union

May 11 A roentgenogram showed definite callus formation, although it was apparently less in amount than in the control animal, series III, B The blood calcium was 11 mg per hundred cubic centimeters of serum (It is interesting to note that this animal became pregnant at a later date and died in tetany)

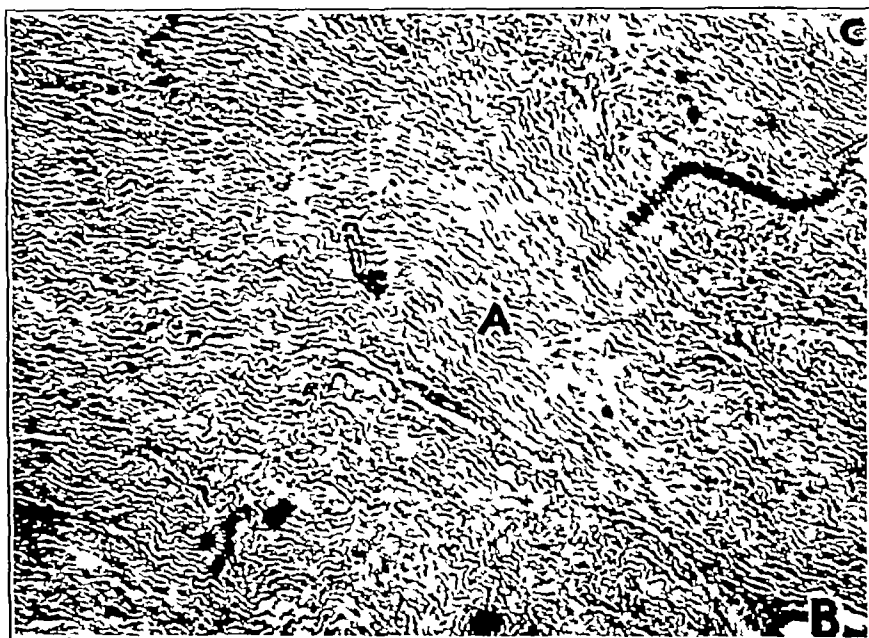


Fig 6 (cat 101)—Section of the membrane formed at the site of the fracture twenty-three days after the break. *A* indicates connective tissue, *B*, new blood vessel and *C*, cartilage Note that no new bone formation is seen in this section

*Cat B*—March 23, 1926 An adult female cat with a blood calcium of 10.8 mg per hundred cubic centimeters of serum was used One external parathyroid was removed from each side The left radius and ulna were fractured A starch bandage was applied

March 25 The animal took food freely There was not any evidence of tetany The bandage was removed

March 30 The broken leg was held off the floor The blood calcium was 10.7 mg per hundred cubic centimeters of serum

April 10 The injured leg was now put to the floor and the animal moved about freely Union was apparently firm, as tested by handling The blood calcium was 11 mg per hundred cubic centimeters of serum

*Cat C*—March 23, 1926 An adult female cat was used as a control animal for cats *A* and *B*, series III The left radius and ulna were fractured and a starch bandage applied

The two cats that were allowed to live more than thirty-five days showed bony union. In one of them the periosteum had been removed as carefully as possible, in the other it had simply been stripped. In the three animals killed in less than thirty-five days, bony union was not present. In two of these the slides looked as if a new joint were being formed, but it was difficult to be sure.

Apparently, though the experiments are too few to determine this, the result of stripping the periosteum is the same as of removing it.

Most of the activity in new bone formation after fracture with overriding is on the outside of the two cortices facing each other. In this bone formation the periosteum does not take part. The internal or medullary callus does not play an active part.

March 22 The animal's health remained excellent. There was no evidence of union of fracture, as tested by handling, nor did the animal attempt to apply the injured leg to the ground. The neck wound was completely healed, there was no infection.

March 30 The animal still walked on three legs. There was no evidence of bony union of the fracture. A roentgenogram showed a slight haziness at the site of the fracture, but no definite callus formation.

March 31 The blood calcium was 9.6 mg per hundred cubic centimeters of serum. The animal walked on three legs. There was no evidence of bony union, as tested by handling.

April 5 The general health of the animal was good. The broken leg gave one the impression of a pseudoarthrotic joint.



Figure 9

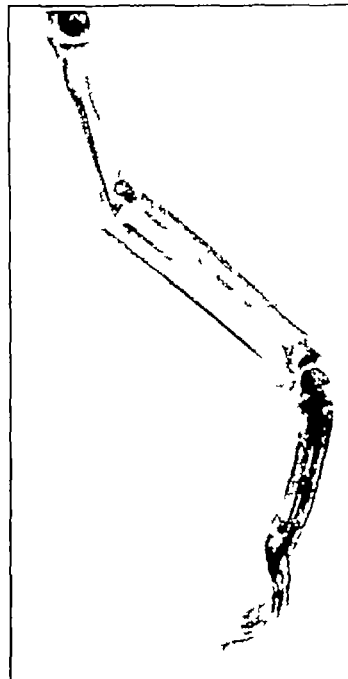


Figure 10

Fig 9 (series I, cat C)—Twenty-one days after fracture. The arrow indicates callus.

Fig 10 (series II, cat A)—Nineteen days after fracture.

April 10 The animal walked on three legs and did not attempt to bear any weight on the injured limb.

April 15 There was no appearance of bony union. The general health of the animal was good.

April 18 The blood calcium was 10.2 mg. The mobility at the site of the fracture was not so marked as previously. The animal now put the leg to the floor.

[ED NOTE—It is not necessary to remove all ureteral stones in performing nephrectomy and partial ureterectomy. If the ureter is not dilated or markedly infected, small, partially obstructing stones in the lower part of the ureter do not cause trouble. Complete nephro-ureterectomy is a much more extensive procedure than simple nephrectomy and adds greatly to the operative risk. Dilated ureters containing large stones should be removed at the time of the nephrectomy if the patient is in good condition, or they may be removed later if they cause pain or urinary infection.]

Large ureteral stones are only rarely seen in this period of accurate urologic diagnosis. In 1909, Federoff<sup>31</sup> reported a case in which the stone weighed 52 Gm. In 1910, Porter<sup>32</sup> reported a case in which the stone weighed 95 Gm. Israël<sup>33</sup> removed a ureteral calculus 17 by 2 cm.]

Rathbun<sup>34</sup> reported a case of bilateral diverticula of the ureter. The patient, a boy, aged 10, complained of dysuria and frequency. The urine was highly infected, and cystoscopy revealed general diffuse cystitis. A roentgenogram after ureteral catheterization showed the catheters on both sides coiled up in a diverticulum. At operation, a somewhat enlarged and much thickened bladder was fully exposed and freely mobilized through an extraperitoneal, median incision extending from symphysis to umbilicus. The diverticula were found in the depths of the wound buried in a mass of adhesions, particularly on the right side where the diverticulum was with difficulty dissected free from the seminal vesicle. The sac apparently consisted of the lower end of the ureter communicating with the bladder through a tiny opening at the normal site of the proximal end of the intramural portion and above with moderately dilated and much thickened ureters. The sacs and about 4 cm. of the ureter immediately above were excised, and the bladder openings closed with a single chromic suture. The bladder was opened through a slit made near the summit. The ureters were reimplanted fairly high in the posterior wall. A Pezzer catheter was anchored in the bladder, rather free prevesical and perivesical drainage were established and the usual closure made around the drains. The diverticular sacs were lined with transitional epithelium continuous with, and of the same type as, the epithelium lining of the ureter itself,

31 Federoff, S. P. Zur Kasuistik der Ureterstein, *Ztschr. f. Urol.* 3: 65, 1909.

32 Porter, M. F. Kidney and Ureteral Stones, *J. A. M. A.* 55: 1691 (Nov. 12) 1910.

33 Israël, quoted by Pappa, A. Contribution à l'étude des calculs de l'uretère, *Ann. d. mal. d. Org. Gen. Urin.* 26: 1694, 1908.

34 Rathbun, N. P. Bilateral Diverticula of the Ureter, *J. Urol.* 18: 347, 1927.

March 30 She walked with a slight limp When jumping from a height of from 4 to 5 feet she used both front legs to alight on Union, as tested by handling, was firm

April 5 The union was solid and the animal moved about freely

*Cat C*—March 11, 1927 An adult female cat was used as control for cats A and B, series IV The blood calcium was 108 per hundred cubic centimeters of serum The left radius and ulna were fractured and a plaster bandage applied

March 12 The animal had not completely recovered from the anesthesia There was not any evidence of tetany

March 13 The bandage was removed The cat took food

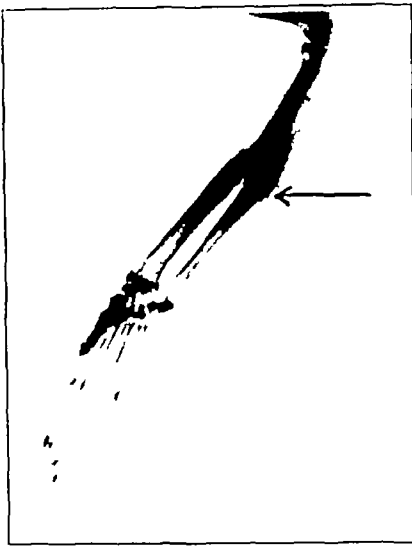


Figure 13

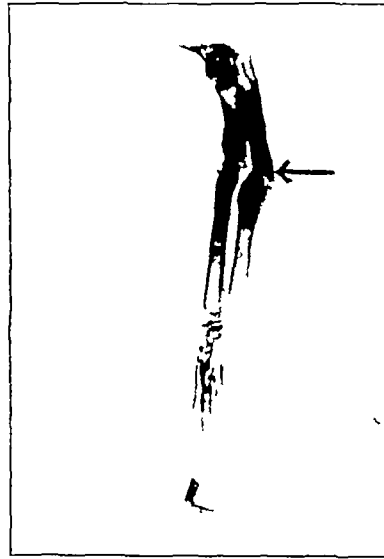


Figure 14

Fig 13 (series III, cat A) —Forty-nine days after fracture The arrow indicates callus

Fig 14 (series III, cat B) —Forty-nine days after fracture The arrow indicates callus

March 14 The general health was good The blood calcium was 107 mg per hundred cubic centimeters of serum The animal did not put her injured leg to the ground

March 17 The animal held the injured leg off the floor when walking

March 22 She walked with a limp, and on palpation of the fracture a certain amount of thickening was perceptible, although slight angulation at the site of the injury could be obtained if pressure was applied to the lower fragment

March 30 The cat walked with a barely perceptible limp A roentgenogram showed a definite deposit of callus There was firm bony union, as tested by handling

April 5 The union was solid and the animal moved about without any disability



Earthy incrustations around the neck of the bladder were sometimes present. The stone, stones or gravel varied in weight in individual cases from 17 to 27 mg in males and from 8 to 35 mg in females. The largest single stone weighed 35 mg, a stone of proportionate size in man would have weighed about 0.5 Kg. Chemical examination showed the calculi to consist mainly of earthy phosphates (calcium and magnesium) along with traces of calcium oxalate. Stone was found only in animals that died between the eighty-fourth and the one hundred and fifty-seventh day of the experiment, the onset of the disease did not appear until fifty-six days after the initiation of the diet.

During the 157 days this experiment lasted, 340 postmortem examinations were made on rats that had been fed in various other ways. In none of these was stone present in the bladder.

Bikovtseva<sup>36</sup> stated that vesical calculi are most common during childhood, they are rare in middle age and again more common after the age of 40. They are much more common in males than in females. Most stones can be removed through the urethra or by crushing. If these procedures are not successful in women, colpocystotomy can be performed.

*Diverticulum*—Davis<sup>37</sup> reported a case in which a large diverticulum of the bladder was drained suprapubically. Later the diverticulum was resected by an ingenious method, a Young prostatic retractor was inserted in the sinus and traction put on the diverticular sac which permitted it to be dissected free. The prostate was also removed, following which further urinary difficulty did not occur.

[ED. NOTE—The diverticulum in this case was very large. Small diverticula are generally rounded or oval, and lie between the bladder and rectum extending laterally and upward as they increase in size. It is usually only very large diverticula that come to lie above the bladder. In about 30 per cent of cases, it is necessary to perform prostatectomy as well as to excise the diverticulum. Usually if the multiple stage operation is carried out, these two procedures give good results and are attended by a comparatively low mortality rate.]

Kaufer<sup>38</sup> noted that diverticula of the bladder are common and are usually concerned with urinary obstruction, increased intravesical pressure and lowered resistance of the wall of the bladder. They occur as bulgings of mucous membrane through the muscle bundles. Kaufer

36 Bikovtseva, M. J. Blasensteine bei Frauen, Medizin Obozr. Nizhn. Povolzhya Astrachan, 1926, obstr. Ztschr. f. Urol. **21** 475, 1927.

37 Davis, D. M. Preliminary Diverticulostomy in Diverticulum of Bladder. Unusual Case and Method of Operation, J. A. M. A. **89** 192 (July 16) 1927.

38 Kaufer, L. Ueber ein ungewöhnlich grosses Blasendivertikel, Ztschr. f. Urol. **21** 430 1927.

brane (with all the muscles removed) allowed of lateral movement at the site of the fracture, it did not allow any extension unless it was torn across by the force of the pull. It was easily cut through with a scalpel and did not offer any hard resistance. Sections were taken for microscopical examination, and these did not require to be decalcified previous to cutting with the section knife.

Blood phosphate determinations both before and after the removal of either two or three parathyroids did not reveal any change in the blood phosphate level.

In addition to the four series of experiments described, other less complete series were carried out. These latter, complicated by failure to effect clean removal of the parathyroid glands or by other misadventure,

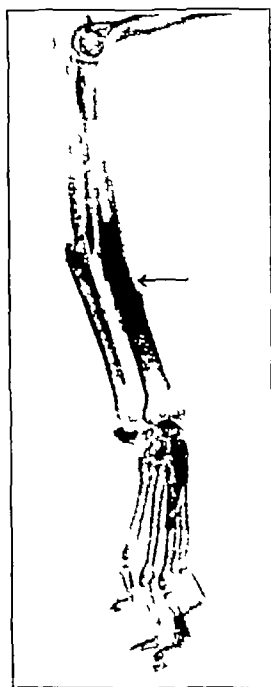


Fig. 17 (series IV, cat A) —Thirty-eight days after fracture. The arrow indicates callus.

have not been considered worthy of detailed description. At the same time it is well to mention that no exception to the foregoing general observations occurred in any single case, and delayed union was present only when three parathyroids had been removed.

The results obtained from these experiments, as exemplified by the accompanying histories, show that if two parathyroids are removed either from the same side or one from each side, there is no delay in the time of deposition of callus at the site of fracture as compared with the control animal. In the animals in which three parathyroids are removed there is little, if any, deposit of callus (as determined by

Targett<sup>41</sup> cited Green's case, in which the diverticulum held about 4 liters of urine Potherat<sup>42</sup> reported a case in which a sac held 5.5 liters ]

*Tumors*—Wade<sup>43</sup> stated that the majority of vesical tumors cause symptoms at an early stage Casper used the cystoscope in 142 cases of tumor of the bladder immediately after the first attack of hematuria, all but three were small early tumors

Vesical tumors with papilliform ingrowths are of three varieties innocent, transitional and primarily malignant The first is the innocent, villous papilloma The second is the malignant papilloma which appears always to evolve after a longer or shorter interval out of the innocent villous papilloma The third is primary papillary carcinoma

The appearance presented by a benign villous papilloma of the bladder may be compared to an oak tree Sometimes it is viewed from above, sometimes from the side In the latter case its well proportioned stem is seen beneath the overhanging branches of the growth To view this stem, however, it is sometimes necessary to push aside the long, low-hanging, waving branches, and as these gently wave in the fluid medium the delicate peripheral leaves proclaim the innocence of the growth If the area around the base of the growth is seen to be roughened, vascular and granular, this appearance is suggestive of early malignant change This "brushwood" area is the site from which a recurring crop of young seedlings spring, and ultimately may be the site of a more malignant new growth If an innocent villous papilloma has undergone malignant change, it is not easy at first to recognize the transformation Later, however, the appearance is more characteristic The delicate branched villi become fused into a more uniform mass with a roughened surface The stem is no longer trunklike, the growth is more sessile The surrounding area is irregular and granular, and ultimately the surface of the growth may become ulcerated with a gray slough covering one part Primary papillary carcinoma is sessile, with an irregular, excavated, ulcerating surface Primary epithelioma of the bladder has the appearance of a malignant ulcer, while adenocarcinoma presents an excavated center with overhanging margins

The treatment for tumors of the bladder is determined by their nature, size and extent of dissemination There is only one form of treatment indicated for a benign villous papilloma of moderate size,

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41 Targett, J. H. Abstract of a Lecture on the Pathology of Cystic Tumours Connected with the Bladder, *Brit. M. J.* 2 218, 1893

42 Potherat, quoted by Gayet, G., and Gaulhier, C. Les diverticules de la vessie, *J. d'urolog. med. et chir.* 14 293, 1922

43 Wade Henry. The Treatment of Tumours of the Urinary Bladder, *Tr. Med.-Chir. Soc. Edinburgh, 1926-1927*, *Edinburgh M. J.* 34 1, 1927

3 The excision of two parathyroids does not diminish the blood calcium level, while the excision of three parathyroids causes a drop of from 2 to 3 mg of calcium per hundred cubic centimeters of serum

4 When the blood calcium returns to normal level bony union of the fracture occurs

5 The removal of two or three parathyroids does not influence the blood phosphate level

6 A certain amount of mobility at the site of the fracture is not deleterious to bony union

In the filtrating type, the margins slope outward to meet the mucosa and burrow down into the wall of the bladder. These tumors are generally firm and compact, and without a tendency to split in cleavage planes. The only difference in the histology of the solid tumors is that most of the infiltrating tumors show none of the remnants of papilloma commonly seen in papillary carcinoma.]

*Leukoplakia*—Hennessey<sup>44</sup> reviewed seventy-nine cases in the literature and one of his own of vesical leukoplakia associated with vesical calculus, right infected hydronephrosis and a severe infection of the urine by *Bacillus coli*. He believed that chronic inflammations, irritations and calculi are important factors in the production of leukoplakia. In the urinary tract, leukoplakia is most commonly found in the bladder. The lesion is more common in the male, the ratio being about 3:1. Pathologic observations indicate a precancerous tendency in the area affected by leukoplakia. Treatment has been variable and uncertain. Fulguration of the vesical lesions has been thought to be beneficial.

[ED. NOTE—Leukoplakia has long been a subject of interest and conjecture because of unknown etiology and pathologic significance. The occurrence of such a process in the urinary tract, reproducing exactly the microscopic and gross appearance of skin, together with its relative rarity, renders any study important which helps to explain the etiology of this unusual condition. The urinary tract is embryologically of entodermal and mesodermal origin, whereas leukoplakia is an epithelial process (ectoderm). The interest in the subject led to an extensive review by Hinman, Kutzmann, and Gibson,<sup>45</sup> whose views and observations have been further substantiated by Hennessey. Leukoplakia has been found usually to be associated with inflammation of long standing, calculus formation or other irritation, which seem to be the usual contributory factors.]

The etiology is unknown. The most common theories are:  
1. Leukoplakia is a time metaplasia on the basis of chronic inflammation and irritation, or the biologic process of adaptation to environment in the form of protective cornification.  
2. Leukoplakia of the urinary tract arises on the basis of misplaced embryonal rests of primitive ectoderm.

The symptoms are those of infection of the urinary tract (cystitis, pyelitis, pyelonephritis, pyonephrosis) and urinary lithiasis, conditions with which leukoplakia is usually associated. The treatment of choice

<sup>44</sup> Hennessey, R. A. Leukoplakia of the Bladder, *J. A. M. A.* **88**: 146 (Jan. 15) 1927.

<sup>45</sup> Hinman, Frank, Kutzmann, A. A., and Gibson, T. E. Leucoplakia of the Kidney Pelvis with Reports of Two Cases, *Surg. Gynec. Obst.* **39**: 472, 1924.

on the anterior surface of the thigh from which the grafts had been taken. The grafted area (fig 1) on the lower posterolateral surface of the leg was irregular in outline and about 4 by 8 cm in area. The grafted skin was fairly movable over the underlying tissue and was thrown into numerous fine folds or wrinkles. The depression of the surface was almost negligible, but there was an easily detected lack of moisture. Some portions of the graft were lighter, while others were more deeply pigmented than the surrounding skin. Sensation to temperature, pain and deep pressure was only slightly diminished, but sensitivity to light touch was considerably impaired.



Fig 1—Appearance of the leg thirty years after grafting by the method of Thiersch.

The urethral growth was well advanced on her admission to the hospital, and radium therapy influenced it but little. When it became evident that the patient would be confined to bed for the remainder of her days, she readily consented to a removal of sections from the grafted areas, from the area from which the graft was taken and from the normal skin of the opposite leg. The specimens were excised with a sharp knife and the edges of the wounds closed. Primary healing occurred, and the patient was none the worse for the procedure. The sections were fixed, mounted and stained by the usual methods and a study made of each.

[ED NOTE—Negley's statistics compare favorably with those reported by other authors. Twenty or thirty years ago, almost all cases of rupture of the bladder were fatal. In 1887, Ullman<sup>47</sup> reported only twenty-two recoveries in 237 cases. Ninety-four of these were extraperitoneal, twenty patients recovered. Only two of 143 patients with intraperitoneal rupture recovered. Bartels<sup>48</sup> reported a mortality of 96 per cent in ninety-eight patients treated without operation. Dobrowolskaja and Wiedemann<sup>49</sup> reported sixteen cases in which six patients were operated on within twenty-four hours from the time of injury, one (16 per cent) died, the other ten were operated on in from forty-eight to 120 hours after injury, 90 per cent of these died. Two hundred and twenty-eight (45 per cent) of 504 cases reported by Packmayr<sup>50</sup> ended fatally. One hundred and fifty-one (90 per cent) of 169 cases of rupture without external wounds ended fatally. In contrast to this, stab wounds or gunshot wounds of the bladder end fatally in only from 22 to 24 per cent of cases.]

Cassuto<sup>51</sup> reported a case in which a fairly large vesical tumor was treated with a high frequency current of about 400 milliamperes. The bladder contained 150 cc of fluid. During the procedure, a fairly strong explosion occurred in the bladder which even the patient heard, although he did not feel any pain. The bloody contents were removed from the bladder and a retention catheter put in. Slight hematuria occurred for five days without any further untoward symptoms. Cystoscopy eight days later revealed edematous mucous membrane with diffuse furrows spreading over the entire mucous membrane and even extending into the muscular layers.

Bitschai<sup>52</sup> discussed two groups of cases of vesical rupture, one traumatic, the other spontaneous. The former is due to external force. It is rare for the latter to occur, except in cases of disease of the central nervous system from a lesion in the wall of the bladder or the urethra (such as tuberculosis, tumor, hypertrophy of the prostate or stricture).

A case was cited in a man, aged 57, with a history of a former gonorrheal infection. For some time he had had difficult urination with

47 Ullman, E. Ueber durch Fullung erzeugte Blasenrupturen, *Wein med Wchnschr* **37** 749, 794 and 823, 1887.

48 Bartels, M. Die Traumen der Harnblase, *Arch f klin Chir* **22** 519 and 715, 1878.

49 Dobrowolskaja, N., and Wiedemann, H. Zur Frage der intraperitonealen Harnblasenrupturen, *Beitr z klin Chir* **89** 700, 1914.

50 Packmayr, O. Rupture of the Bladder and Its Treatment, *Am J Urol* **5** 253, 1909.

51 Cassuto, A. Explosion dans la vessie au cours d'une electro-coagulation, *J d'urol med et chir* **22** 263, 1926, abstr *Ztschr f Urol* **21** 393, 1927.

52 Bitschai, J. Spontanruptur der Blase, *Ztschr f Urol* **21** 461, 1927.

papillae corium were supposed to be cut across in the classic thin graft, there would be little undulation of the stratum germinativum when its continuity was reestablished by a lateral extension from the basal cells over the apexes of these papillae. The depth of the papillae was diminished by the operation, and this accounts for the shallowness of the rete pegs in the area from which the graft was taken. The fact that an attempt was made to include as little of the corium as possible explains the absence of glands and follicles in the graft. Unintentional injury to the corium would produce atrophic changes in some of the structures in the area from which the graft was removed. The varying diameter of the stratum corneum in the three sections was directly proportional to the supply of glands and the relative degree of moisture.

#### SUMMARY AND CONCLUSIONS

After a period of thirty years, a Thiersch graft on the posterolateral surface of the leg of a laundress was found to give excellent protection and a fair cosmetic result. Sensation was only moderately impaired, but secretion and excretion were entirely lost, and for this function the graft was entirely dependent on the adjacent skin. A histologic study disclosed results which were in keeping with the amount of tissue transplanted and the processes involved in its successful conclusion. It would seem that a whole thickness graft would be the method of choice in most instances, because more structures of the corium would persist and thus permit the function of the transplant more closely to approximate the normal.

24 Doctors' Building



## PROSTATE

*Hypertrophy*—Randall<sup>54</sup> initiated a discussion on the origin and situation of prostatic hypertrophy citing the work of Tandler and Zuckerkandl, Albarran and Motz. Motz and Pearnearneau, Lowsley and others, pointed out that there has been a tendency to believe that the hypertrophying prostate consistently originated in only one situation. From a series of 1,218 necropsies, conclusions were drawn that it was impossible to correlate the data with the idea that the hypertrophy invariably originated in any one fixed area. Hypertrophy may originate in any lobe except the true posterior lobe, in which case the data from this series must give definite types of hypertrophy, according to its origin, that is, lateral lobe hypertrophy, hypertrophy in the posterior commissural glandular tissue, hypertrophy in the subcervical gland of Albarran or combinations of any or all should be found. According to Randall, lateral lobe hypertrophy has always been bilateral, although occasionally one lobe may be larger than the other. Specimens were found showing only involvement of the middle lobe, and when this occurred, the hypertrophy of the middle lobe partook of a different contour according to whether the origin was in the posterior commissural tissue or in the subcervical gland of Albarran. In other words there are two glands present anatomically in the median line posteriorly, either of which may undergo hypertrophy independently of the other, or independently of the lateral lobes. These can be recognized through the cystoscope or at operation. The differential diagnosis of these types is made cystoscopically and rectally.

There are differences of surgical procedures according to the presenting type. Preoperative recognition should alter the surgical approach in order to cause the least amount of injury, permit clean enucleation and minimize the probability of postoperative hemorrhage. These factors likewise could not but influence the completeness and permanency of cure and decrease definite postoperative morbidity which has so regularly followed prostatectomy.

When only bilateral hypertrophy is present during the suprapubic operation, each lobe should be separately enucleated, in hypertrophy of the lateral lobes and posterior commissure, enucleation starting about one lobe should follow the line of the false capsule under the posterior commissure and across the median line and the apex of the trigone and thence directly into the line of cleavage and about the opposite lateral lobe, the hypertrophic tissue being removed en masse. If there is hypertrophy of the subcervical glands, it being recognized that these lie without the normal prostatic capsule and are covered only by mucous

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<sup>54</sup> Randall, Alexander. Commissural Prostatic Hypertrophy, *Am J Surg* 2: 478, 1927.

consideration. The others died or were killed at intervals. The humerus, with the surrounding soft tissues, was removed and placed in a solution of formaldehyde, and then in alcohol. It was decalcified in 5 per cent nitric acid, run up through alcohol, dehydrated with ether, mounted in celloidin and stained with hematoxylin and eosin and with the van Gieson stains.

#### EXPERIMENTS

CAT 46—Duration of experiment, thirty-two days

*Operation*—The incision was made posterior to the deltoid muscle and the long head of the triceps down to the humerus. As much of the periosteum was removed as was possible for a distance of about a centimeter. The humerus was divided with Liston forceps, and the periosteum was scraped for a distance of about 7 mm from the end of each fragment. The wound was closed with deep chromic and superficial plain catgut. Collodion dressing was applied.

The animal was found dead thirty-two days later. The wound had healed by first intention, and signs of infection were not present. The fragments were freely movable, and much deformity was present with overlapping.

*Microscopic Study*—The fragments overlapped about 2 cm, and did not lie closely together. They had been caught somewhat on the bias by the knife, so that it was necessary to study two slides to get the exact facts. The end of each fragment had been shut off by fibrous tissue, which stretched across the open marrow canal in irregular bundles and ran for a short distance down into it. Irregular bone trabeculae were scattered in the marrow canal of each fragment, but it was impossible to tell whether or not these were newly formed. The periosteum could be traced almost to the end of the inside cortex (that is, the cortex on the side adjacent to the other fragment) of one fragment and to the end of the outside cortex of the other fragment. In the latter, it was continuous with the fibrous tissue plugging up the marrow canal. Each bone showed a subperiosteal callus near the end of its outside cortex. The cortices of both fragments had a rather openwork structure near their ends, apparently the beginning of the rearrangement of the bony tissue. The space between the two fragments was filled with fibrous tissue and cartilage, but little sign of ossification appeared in this. From the appearance of the slide, it was possible that bony union would have taken place in time.

*Result of Experiment*—Thirty-two days after removal of the periosteum, as nearly complete as possible, a false joint was found.

CAT 47—Duration of experiment, 119 days

*Operation*—An incision was made like that in cat 46, and the same type of operation was performed except that the periosteum was separated from about 7 mm of the end of each fragment, and little of the periosteum was actually removed.

When the cat was killed, he was able to walk on the leg without a limp. The fracture apparently was united, with considerable overriding.

*Microscopic Study*—The two fragments were firmly united by bone. The bony callus had reached such a state of development that it was fairly dense at its periphery, and spongy within. The cancellous bone possessed marrow with the same appearance as that within the marrow canals of the fragments themselves. Rearrangement of the bone had proceeded so that the distinct outline of the fragments was difficult to make out, but apparently one had been caught on the

and are seriously affected because they suffer from frequency. Such cases need careful observation. True enlargement of the middle lobe is rare. Before Hinman's modification of the technic of operation Lowsley operated on 40 per cent of his patients suprapubically for the simple reason that when the subcervical gland was involved, the mass could be better removed suprapubically in its entirety. Hinman's modified technic affords better exposure of the prostatic bed and vesical orifice and in most instances it is possible to remove large subcervical masses. He had already removed one about 7 by 5 cm. Lowsley said that it is interesting to have Randall agree so thoroughly to views suggested by himself from the embryologic point of view and that Tandler had changed his ideas to make them fit the embryology which had been studied more thoroughly since he and Zuckerkandl first studied the prostate. Their studies were accurate but the embryologic studies of the prostate had made it possible to explain the pathologic conditions much more satisfactorily.

Morton felt that he could not entirely subscribe to Tandler and Zuckerkandl's work especially in view of the excellent paper of Randall's. Three years ago he did some work on hypertrophied prostates in Professor Bauer's laboratory in Vienna and could not make the facts fit Tandler and Zuckerkandl's theory. He had found the hypertrophy of tubules and muscular fibers extending entirely through the prostate in all lobes and failed to find the thinned out remains of the original prostate at the periphery. He could not explain these facts at that time but from Randall's paper he was convinced that the hypertrophic change in the prostate may be universal and not confined to one group of glands, or it may affect one limited portion of the gland.

Morrissey supplemented Randall's paper by showing the specimen of a patient, aged 42, who had suffered from retention for five years and on whom the Young's punch operation had been performed three years previously. He was temporarily relieved by the operation but three months before Morrissey showed the specimen there was again 40 cc of residual urine. Young's punch operation was performed without much benefit and the bleeding continued for three months. Perineal prostatectomy was then performed and a large growth of the posterior lobe was removed. Although it did not correspond to the Albarran type it had a lamella of its own separated from the two lateral lobes. The bladder did not empty until this was removed. On the upper surface there was a small indentation where a piece of fair size had been removed by the Young's punch. Morrissey said that he has not had much success with Young's punch possibly because the cases were not properly selected. Morrissey has used Braasch's instrument with some success using the Bumpus method of fulguration of the prostatic area to check bleeding.

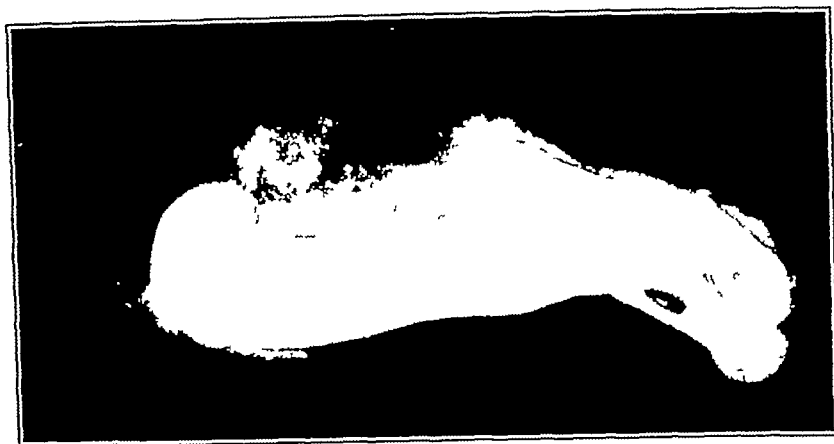


Fig 3 (cat 47) —Roentgenogram of the specimen



Fig 4 (cat 47) —Bony union. A new cortex has already formed about the bony callus. If this were an isolated experiment one might claim that the cortex had been formed by the periosteum. Note the partially completed absorption of the adjacent cortices.

factory surgical methods. The day is past when bladder wounds are encrusted with phosphates and the surrounding skin inflamed and ulcerated. Some of the commoner septic complications are cystitis, epididymitis, seminal vesiculitis, pyelitis and pyelonephritis. Thomson-Walker has found that the number of cases of enlarged prostate in which the bladder has been infected by catheter is much smaller than it was ten or fifteen years ago, but it still amounts to 44 per cent in private practice and 53 per cent in hospitals. He believes that few cases need the two stage operation.

Cholesterol plays an undefined part in the process of immunity, stimulating the production of antibodies. Immunization processes have been shown to be accompanied by a high cholesterol content of the blood, low "blood cholesterol" in a case of acute or chronic retention due to prostatism is significant of low capacity for antibody formation and suggests that the patient is a poor operative risk. The combination of high blood urea and a low cholesterol content is serious. Certain factors, however, such as arteriosclerosis, glycosuria and malignancy, produce a high cholesterol content, and therefore tend to modify its significance. The normal average cholesterol content of the blood is 0.161 per cent and less than 0.130 per cent is abnormal. MacAdam and Shiskin found that sixteen of eighteen patients whose blood cholesterol was less than 0.130 per cent died from pyelonephritis, the other two recovered.

The sources of sepsis are (1) dislodgement of bacteria into the blood from the rectal wall during enucleation, (2) postoperative tags, shreds and partly detached nodules of prostate glands, capsule, urethra and mucosa, forming centers of sepsis and masses of slough, and (3) postoperative suprapubic wound.

Obstruction following suprapubic prostatectomy varies from slight difficulty in micturition to complete retention with suprapubic fistula. Thomson-Walker has classified these obstructions as follows: (1) fibrous contraction, valvular folds or adenomatous nodules at the vesical neck or in the prostatic lobe, and (2) new growth in the wall of the lobe of the prostate due to recurrence of simple enlargement of the prostate or malignant growth.

[ED. NOTE—Thomson-Walker has been one of the foremost exponents of the suprapubic methods of prostatectomy and has obtained excellent results. In an earlier publication he stated that in ordinary cases without pronounced renal impairment or severe infection, the two stage operation is certainly not safer than the one stage. In the average prepared case hemorrhage is not more common in the one stage operation, and no advantage need be expected from cystotomy. Two stage operations were performed in only sixty-three (7.6 per cent) of a series of 820 of his cases. The patients had chronic urinary retention, sepsis

of any bone formation at the end of the open marrow canal. On the outside of one cortex there was a large fragment of bone which was evidently splintered off at the time of the operation, and which had worked its way down along the side of the cortex. On the far cortex of one fragment a rather long strip of new bone formation could be seen under the periosteum. This new bone ceased at some distance from the end of the fragment fairly abruptly and did not appear to be playing any useful part in the healing process. It seemed to be developing from fibrocartilage, and for some distance from the place where it ended, the gap between the cortex and the periosteum was filled with cartilage and fibrous tissue. On the cortex of this fragment, facing the other fragment, but at some distance from the end, was a sort of semicircular collection of fibrin and fibrous tissue,



Figure 6

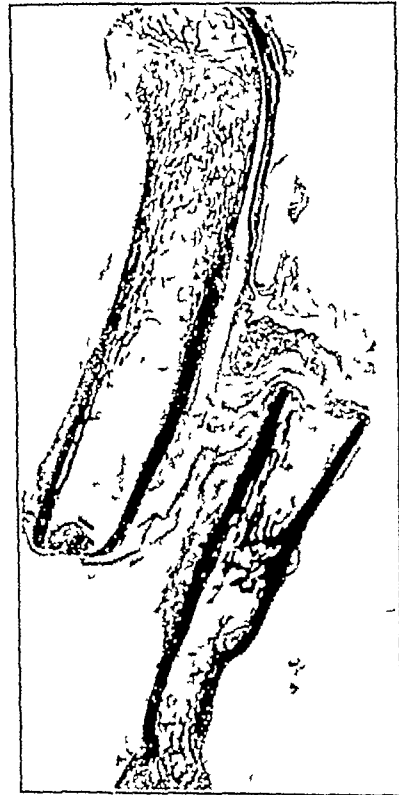


Figure 7

Fig 6 (cat 48) —Nonunion. Note the irregular masses of new cartilaginous callus on the adjacent cortices with a distinct cleft between them. This specimen illustrates all the elements of a false joint.

Fig 7 (cat 50) —False joint. Note the new bony and cartilaginous callus on one of the adjacent cortices.

and on this near cortex a few new bone trabeculae had been formed. On the corresponding cortex of the other fragment there was a large mass of cartilage and fibrocartilage in which new bone formation had been active. On the far cortex of this fragment, but nowhere near its end, a few new trabeculae had been formed. New bone trabeculae in the form of an internal callus were also in evidence in this fragment, but in irregular formation. The two fragments were separated by fibrous tissue loosely arranged and with long slits in it, and the

the casual operator should continue to use the old method of post-operative suprapubic drainage

Lewis agreed with Chute. He said

It seems to me that the field for this method would be limited, not only because of the need for expertness on the part of the operator, but as related to the patients themselves. In the septic bladder I would hesitate to have it attempted even in the hands of Dr. Lower for they will almost surely open up. I have tried sewing up the bladder following suprapubic operations and discontinued the practice as unsatisfactory and undesirable.

Randall said

I think Dr. Chute is correct. Dr. Lower's manual skill at the operating table is equaled only by his artist in depicting the closure. I do not know how often he sees these big gaping wounds, but I think that is not the experience of most of us. I wish to criticize the procedure from several points of view: first, one's ability to observe and place the sutures as he has depicted it; second, the advisability of leaving suture material in such an operative field; third, the question of sewing at all through the thin lamina of tissue with the rectum in such close proximity. Whether he gets primary healing I doubt, but a fourth point could be raised that he is forming an artificial sphincter according to his judgment but not according to nature. These critical points are mostly academic, but there is one thing that all urologists have fought for twenty years, and if everything else was denied us we would hold to it alone, for if there is any one thing that has changed mortality in this type of surgery, that one thing is drainage. We all know what it means in these cases to drain preoperatively, and I think, yes, I positively know, that it will be a great fault to withdraw that drainage postoperatively.

Goldstein,<sup>57</sup> being impressed by the relative frequency of epididymitis after prostatectomy and following the work of Morson, has made a careful study of ligation of the vas deferens prior to prostatectomy.

Bilateral ligation and section of the vas deferens was performed in five one stage, seven two stage, and thirteen perineal prostatectomies as compared with no ligation in eleven one stage, nine two stage and five perineal prostatectomies. In the sixteen one stage prostatectomies in which the vas deferens of eleven cases was not ligated, epididymitis developed in four, while in sixteen cases of two stage prostatectomy in which the vas was ligated in seven and not ligated in nine, epididymitis did not develop. The epididymitis in the five cases without ligation made its appearance in from thirteen to twenty-two days after the original prostatectomy, an average of eighteen days. The complication in the one perineal case in which ligation was performed came on the thirty-fourth day after operation and after the patient had returned to his home.

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<sup>57</sup> Goldstein, A. E. Bilateral Ligation of the Vas Deferens in Prostatectomy, *J. Urol.* **17**: 25, 1927.

was forming on the outside of the new cortex under the periosteum. This new bone appeared to be formed from the cortex out of cartilage and fibrocartilage. Dead bone could not be recognized in the slide, and there was no evidence of rearrangement of the bone tissue of the cortex, nor of any osteoclasts, that is, osteoclasts in Howship's lacunae could not be seen.

*Result of Experiment*—A firm bony union resulted after seventy-six days through the medium of cartilage and fibrous tissue after removal of as much of the periosteum as possible without stripping it back. Bone formation apparently occurred from the cortex. There was no periosteal bridge, though at one area a new cortex had partially formed under the periosteum for a certain distance out from the old cortex. There was no evidence of internal callus.

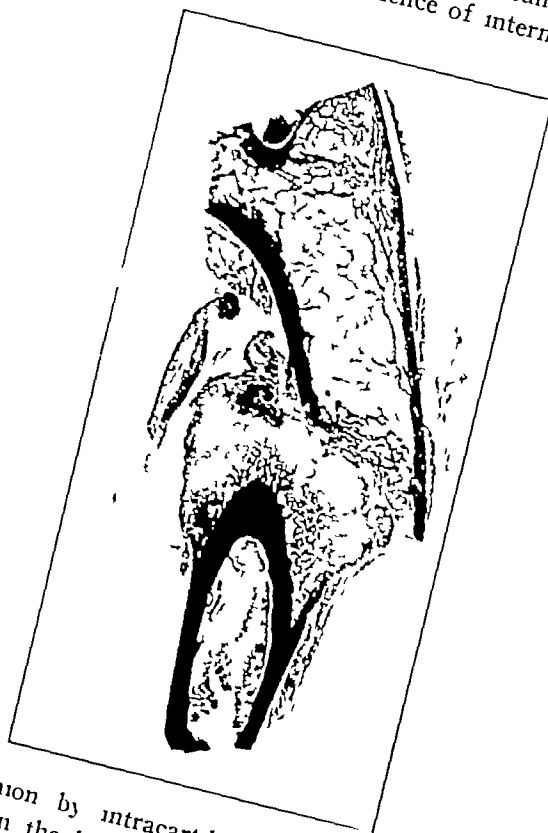


Fig 9 (cat 52)—Union by intracartilaginous ossification. The fragment which has been caught on the bias with the knife shows well the many new trabeculae apparently springing from the cortex. In the other fragment the trabeculae extend into the marrow canal.

#### SUMMARY

The following results were obtained from experiments on five cats: one fracture with removal of periosteum 32 days cartilaginous union, one fracture with stripping of periosteum, 119 days union, one fracture with stripping of periosteum 33 days no union, one fracture with removal of periosteum 25 days no union and one fracture with removal of periosteum 76 days union.



and are not due to good fortune alone or to mere chance. In this connection it is of interest to recall that prostatectomy has not always been the mild procedure that it is today. To quote from Young, "Twenty years ago, the general mortality from prostatectomy was greater than 20 per cent, now it is almost nil." The lowering of this mortality rate is dependent on four factors: (1) the general recognition by the medical profession of the value of preoperative drainage, (2) the growing enlightenment of the public, with consequent knowledge of the increased danger of delay, (3) the increasing popularity of sacral anesthesia, and (4) more careful attention to hemostasis.

Of these four factors, the first is by far the most important. There is unquestionably a lurking danger in attempting immediate prostatectomy, the figures of Hunt clearly show this. In analyzing a series of 1,783 cases of prostatectomy he divides these into three groups: (1) poor risks (preliminary suprapubic drainage) 437, mortality 7.5 per cent, (2) average risks (preliminary catheter drainage) 680, mortality 3.2 per cent, and (3) good risks (without preliminary drainage) 666, mortality 6.6 per cent.

Hunt stated in regard to the relative value of the perineal and suprapubic routes that an unprejudiced analysis of the ultimate functional results and mortality rates following both methods of operation by those experienced in them shows that these indexes of merit can no longer be utilized to discredit one or the other method.

Only one of Davis' patients died in 107 consecutive cases of perineal prostatectomy. One of the cases was persistent perineal fistula. There were no cases of complete incontinence and only three in which the control of urine was not satisfactory. The average age of the patients was 69. There were fifty-three patients more than 70 and ten more than 80.

[ED. NOTE.—As Davis stated, sacral anesthesia is the ideal anesthetic for perineal prostatectomy. After a single caudal injection the maximal point of anesthesia is found to be almost identical to the point of perineal attack. Sacral anesthesia is also an important factor in lowering the mortality rate in suprapubic operations, but due to the greater operative field more extensive anesthesia is required, usually complete sacral block as well as suprapubic block, this injection requires much more skill than the caudal injection and consequently is not used outside of the large clinics as frequently as results warrant. Sacral anesthesia also unquestionably lowers the mortality in the suprapubic operation. The following table shows the mortality in a series of 526 cases from the Mayo Clinic in which operation was performed during a three-year period. This series indicates the desirability of sacral anesthesia over spinal or ether anesthesia.]

## A REVIEW OF UROLOGIC SURGERY

ALBERT J SCHOLL, M D  
LOS ANGELES

E STARR JUDD, M D  
ROCHESTER, MINN

LINWOOD D KEYSER, M D  
ROANOKE, VA

GORDON S FOULDS, M D  
TORONTO

JEAN VERBRUGGE, M D  
ANTWERP, BELGIUM

AND  
ADOLPH A KUTZMANN, M D  
LOS ANGELES

*(Concluded from page 806)*

### URETER

*Ureterostomy*—Papin<sup>29</sup> described a method of anterior ureterostomy for exclusion of tuberculous bladder. The lower end of the ureter was freely liberated, sectioned close to the bladder and brought out through the skin near the anterior-superior iliac spine. The ureteral curve should be long in order to avoid kinking. A cutaneomucous suture is not made, but a portion of the ureter is left protruding above the skin, the portion later sloughs off. A ureteral catheter is left in place until complete cicatrization occurs, it should be closely observed and changed if necessary. In one case, Papin put the ureter in a small pocket made of skin, but it was unsatisfactory as considerable scarring occurred. This type of ureterostomy has been performed from one month to twelve years after nephrectomy, and the operation has not caused any deaths. The vesical pain is immediately and completely relieved, and the anterior site of the operation renders it more bearable than the lumbar site.

*Ureteral Stones*—Cope<sup>30</sup> reported a case of large ureteric calculus. The patient was a lad on whom left nephrectomy had been performed a year previously for pyonephrosis. He complained of continuous pain on that side. A roentgenogram revealed the calculus, which was about 4 by 2 by 1 cm, in the lower end of the ureter, it was probably overlooked at the previous operation. The stone and ureter were removed.

29 Papin. Ureterostomie sur le rein restant, apres nephrectomie pour tuberculose vesicale, Presse med **35** 854, 1927

30 Cope, V Z. Large Ureteric Calculus, Proc Roy Soc Med, Sect Urol **20** 16, 1927

the forefinger and was wider below than above. The lining of this tunnel was smooth and there were numerous small openings, apparently the ducts of glands, in the wall.

The microscopic section showed an appearance like that of an ordinary enlarged prostate gland, namely, gland tubules in groups, dilated and embedded in unstriped muscle and fibrous and elastic tissue.

MacDonald<sup>61</sup> reported the case of a man, aged 68, similar to the case of Thomson-Walker, in which prostatectomy had been performed for an adenomatous enlargement of the gland. A second operation was performed because of hematuria and an adenomatous prostate was removed completely.

[ED NOTE—A number of similar cases of recurrent prostatic enlargement have been reported. Most operations were performed before the technic had reached its present state of precision. In some cases, recurrence of the enlargement was due to incomplete removal of the gland at the first operation. Thomson-Walker performed both the operations in his reported case, a recurrence following prostatectomy by such a skillful operator suggests that true reformation of the gland may occur.]

#### URETHRA

*Tuberculosis*—Wiedhopf<sup>62</sup> reviewed the literature and reported a case of his own. Tuberculosis of the female urethra is exceedingly rare. Von Krzywicki, in 1,246 necropsies from the Dresden Sanatorium, found tuberculous involvement of the various organs in 40 per cent of cases, of these, 5 per cent were urogenital (twenty-nine cases, fifteen men and fourteen women). In only one woman was the urethra affected. Von Pavel gave a similar report of necropsy material from the Breslau Pathologic Institute. The urogenital system was involved in 40 per cent of 1,455 cases of tuberculosis. The urethra was involved in only seven cases, all in men. Schlimpert performed 8,084 necropsies at the Institute of Schmorl, 3,514 (61 per cent) of the subjects were women. Pulmonary tuberculosis was present in 84.3 per cent of these, and urogenital infections in 1.4 per cent, in only one case was the urethra involved. In 1892, Aherns reviewed four cases. Wiedhopf cited a case in a woman, aged 58. Polyps were seen projecting from the meatus. The patient could not be catheterized because of an obstruction by polyps 1 cm from the meatus. At operation, 1 cm of the urethra was resected after which the patient could be readily

61 MacDonald, S. G. Prostatic Enlargement Following Prostatectomy, *Proc. Roy. Soc. Med., Sect. Urol.* **20** 18, 1927.

62 Wiedhopf, O. Strikturierende Tuberkulose der weiblichen Harnröhre unter dem klinischen Bilde eines urethralen Polypen, *Ztschr. f. Urol.* **21** 352, 1927.

which showed numerous small hemorrhagic areas and several small superficial ulcerations. There was definite evidence of inflammatory reaction throughout, and marked hypertrophy of the musculature, both of the wall of the sac and of the ureter.

The patient recovered uneventfully and the wound healed readily. He looks and feels much better. He urinates only once at night and the intervals during the day are as long as three or four hours. There is no dysuria, and while the urine still contains abundant pus it is much clearer than before operation. As both kidneys were undoubtedly affected, Rathbun does not believe that the immediate improvement will be sustained.

#### BLADDER

*Vesical Stone*—McCarrison<sup>35</sup> reported a series of experiments on the production of stone in the bladder. One hundred twenty rats were placed on a diet in which there was (1) absence of protein of animal origin, (2) deficiency of vitamin A and (3) excess of earthy phosphates. To these faults there may have been added toxic action of the diet itself in the urinary tract.

Formation of stones did not occur in rats kept on the diet for a period less than fifty-six days. Twenty-one (seventeen females and four males) of the seventy-two animals kept on this diet for longer than fifty-six days, were found at postmortem examination to have stone in the bladder, the case incidence was 29 per cent. The incidence of the disease varied in the two sexes, being 40 per cent in females and 13 per cent in males. In two other cases in females intense cystitis, but no stones, was present, in one of these there was some earthy incrustation around the neck of the bladder. Hemorrhage from the bladder was occasionally observed during life. In males, protrusion of the penis was a constant symptom in those suffering from stone.

In eighteen cases in which a stone was found, a greater or lesser degree of cystitis was present, in these, the bladder was usually greatly distended and congested. In three cases, cystitis did not occur, showing that the deposition of the phosphatic calculi was not secondary to inflammation of the bladder. In eight cases, the left ureter was much dilated, with associated pyonephrosis or hydronephrosis. Earthy deposits were present in the kidney in four cases, but stones did not form. The stones in the bladder were either single or multiple, as many as five being found in one bladder, they were dirty white, and their surfaces were rough and jagged. Formed stones were not found, or if found, they were so small as to be more properly called gravel.

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<sup>35</sup> McCarrison, Robert. The Experimental Production of Stone in the Bladder, Brit M J 1 717, 1927.

## TESTICLE AND EPIDIDYMIS

*Hydrocele*—Campbell<sup>68</sup> reported a series of 502 cases of hydrocele. He stated that infection and trauma are the chief known causes. Probably painless subacute epididymitis is the underlying factor in many cases. The condition is most common in young adults, in infancy it is usually congenital and associated with hernia. While simple tapping gives relief in many cases, open operation, preferably excision and eversion of the sac, is the procedure of choice. Local anesthesia is most satisfactory in these cases. A hemostatic scrotal compression bandage which is of great service following operation is described.

Simple eversion (bottle operation) is useful in small hydroceles without thickened sacs. In all but seven cases the excision and eversion operation was employed. The mass is delivered through a scrotal incision and incised from end to end. The redundant vaginalis is excised, complete hemostasis is obtained, a running suture being taken in the vaginalis if necessary, and the remaining edges everted and sutured behind the cord. The testicle is replaced in the scrotum, and the skin is closed without drainage. A small gauze dressing is applied, over which is placed the compression bandage, this consists of a four-tailed adhesive bandage which affords support to and, more particularly, compression of the scrotum. The average period in the hospital in all uninfected cases was six and one-tenth days. Many patients were out of the hospital on the fifth day.

Statistics studied from a large number of operators have been compiled by Bruns. When aspiration and injection was performed, the recurrence was 6.1 per cent in 1,593 cases. In 1,216 cases in which open operation was performed relapse occurred in thirty (2.4 per cent).

## URACHUS

*Tumors*—Brady<sup>69</sup> reported a case of solid tumor of the urachus in a woman, aged 43. These tumors are closely allied to tumors of the dome of the bladder and unquestionably are sometimes confused with such tumors. There have been reports, including Brady's series of twenty cases, of solid tumors arising from the urachus. The average age of the patients was 44. The youngest patient was a boy, aged 11, with a primary sarcoma of the urachal sheath, the oldest was a man, aged 82, with an adenocarcinoma of the urachus and secondary involvement of the bladder. These tumors have been found more frequently in men than in women. In this series, the sex of the patients was not recorded in three cases; in three the patients were women; in fourteen men.

<sup>68</sup> Campbell, M. F. Hydrocele of the Tunica Vaginalis. *Surg. Gynec. Obst.* 45: 192, 1927.

<sup>69</sup> Brady, Leo. Solid Tumors of the Urachus. *Arch. Surg.* 14: 46 (Jan) 1927.

cited a case in a man, aged 76, with marked kyphosis and scoliosis, arteriosclerosis, apoplexy and hemiplegia. At necropsy, on opening the abdomen, a large pelvic cystic mass about 15 cm in diameter was found. The kidneys were small. This cystic mass was connected with the bladder. The bladder was markedly dilated, the walls were thickened and hypertrophied and showed coarse trabeculations and cellulose formation. The urine was under great pressure. About 3,000 cc was taken from the bladder and diverticulum. The prostate showed hypertrophy of both lateral lobes, while the middle lobe was about 1 cm in diameter and acted as a valvular obstruction. The diverticulum was 18 by 9.5 by 17.5 cm, its orifice was 3 by 2.5 cm. Histologic examination of the diverticular wall showed an absence of mucous membrane and an increase in connective tissue. In some areas, muscle fibers were found, these were thinner in the dome than in the posterior wall. Kaufer stated that this diverticulum did not cause any symptoms. He differentiated what is termed true diverticulum from false diverticulum. The former contains all the constituents of the wall of the bladder while the latter does not. In this case there were some muscle fibers in the wall of the diverticulum, although in small quantities, and therefore Kaufer considered it true diverticulum. After reviewing the literature, he believed that the diverticulum in his case is the largest true diverticulum on record.

[ED NOTE—Large vesical diverticula sometimes do not cause trouble. They are found at necropsy in old men who have died from other diseases, and who have had little, if any, vesical trouble during life. Apparently as long as the wall of the diverticulum is capable of contracting regularly and emptying its contents, and is not infected, it is a harmless condition. Obstruction of the bladder, retention of urine, infection and the not uncommon sequelae (formation of stone or malignant degeneration) make this abnormality serious, and sometimes rapidly fatal. Harrison<sup>39</sup> reported a case of a man, aged 103, who died suddenly from acute pericystitis which developed following infection of an apparently quiescent vesical diverticulum.

Diverticula vary in capacity from about 1 cc to several liters. While Kaufer's case was unusual, diverticula as large or larger than the normal bladder are not uncommon. Israël<sup>40</sup> recorded the case of a man, aged 66, with a diverticulum three times the size of the bladder.

39 Harrison, R. Saccules and Pouches of the Urinary Bladder, *Internat Clin* 3 243, 1894.

40 Israël, J. Bericht über die chirurgische Abtheilung des jüdischen Krankenhauses zu Berlin, für den Zeitraum vom 1. Januar, 1873, bis 1. October, 1875, *Arch f klin Chir* 20 1, 1877.

## ANESTHESIA

Lower<sup>70</sup> stated that in the field of genito-urinary surgery it has been found that general inhalation anesthesia is not the anesthesia of choice, since in most cases there is either functional impairment or some pathologic condition of the kidney. Lower deprecated the application of any one method of administering anesthesia to the exclusion of others and proposed that the anesthetic be applied strictly according to the patient, that is, that it be adapted to the psychic and physical condition of the patient as well as to the anatomic possibilities of the case.

The anesthetic chosen in genito-urinary surgery and the method of administration must be one of the following: nitrous oxide-oxygen analgesia, ethylene gas anesthesia, spinal anesthesia, sacral anesthesia and local anesthesia. In analgesia produced by nitrous oxide-oxygen, a sufficient degree of relaxation is rarely obtained. While nitrous oxide-oxygen analgesia may be used as an adjuvant, some other method of anesthesia is required, therefore, the choice is further reduced to spinal, sacral or local anesthesia.

Lower believed that spinal anesthesia is more hazardous because of its effect on blood pressure. He placed his chief reliance on sacral block and local infiltration for suprapubic and scrotal operations, and on regional nerve block, local infiltration and nitrous oxide-oxygen analgesia for operation on the kidney.

In operations on the prostate and bladder, sacral block is employed. A 1 per cent solution of procaine hydrochloride combined with 6 minims of a 1:1,000 solution of epinephrine is injected through the sacrococcygeal membrane into the caudal canal, the insertion of the needle being preceded by progressive anesthetization of the path to the caudal canal. Occasionally this is followed by injections through the second, third and fourth sacral foramina on each side. After these injections have been made, the patient is turned over and a complete regional block of the abdominal wall is made. The anesthesia obtained by this method lasts for an hour or more, complete relaxation is secured, and the operation is painless.

If the operative field includes the bladder, the wall of the bladder is infiltrated with 0.75 per cent solution of procaine hydrochloride. If the prostate is to be removed, the procaine is infiltrated between the gland and the capsule, as this helps to separate the prostate from the capsule. Sacral anesthesia, therefore, is of value in all operations on the bladder and prostate, as removal of a diverticulum of the bladder, removal of bladder stone, resection of the bladder, and prostatectomy. If the patient is apprehensive, the anesthetist is prepared to administer nitrous oxide-oxygen until the stage of analgesia is reached.

<sup>70</sup> Lower, W. E. Anesthesia in Genito-Urinary Operations, *Ann. Surg.* 86:268, 1927.

and that is fulguration or destruction by electrical coagulation by a high frequency current carried to it by an electrode conveyed through an operating cystoscope. Wade does not recommend fulguration for primary carcinoma of the bladder. The treatment adopted is determined by the situation and extent of the growth. The most favorable case is that in which the tumor is situated in the summit of the bladder. Tumors in this situation are easily recognized, but it is necessary to make certain that they are not invasions from other organs. Complete excision should be carried out when the growth is primary and on the fundus. If the base of the bladder is involved, it is of the greatest importance to determine the degree of invasion and the extent to which the ureters are implicated. If the prostate in the male is not involved and the growth is reasonably mobile, and one ureter and the bladder around it are free from disease, partial cystectomy may be performed successfully. Half of the bladder may be excised and the ureter on that side implanted into the portion that remains. Wade has had ten such cases, all successful. He stated that the appearance of the bladder at the conclusion of the operation is most unusual, but, if examined some months later, it will be found that nature has successfully restored its shape and contour.

[ED NOTE—Wade's classification of papillary tumors of the bladder conforms to that generally accepted by most urologists. The present tendency is to include most of these tumors in the malignant group, certain pathologists even consider all papillary tumors of the bladder malignant. Areas of malignancy may usually be found even in the small, apparently benign, tumors. In many areas the cells may retain the regularity of benign papilloma, in others they are undergoing various stages of alteration with marked variation in size, type and staining qualities. Some urologists use the size of the tumor as the basis for the type of treatment to be carried out, usually a papillary growth not more than 2 or 3 cm in diameter will respond to fulguration.]

Grossly, the papillary growths may be divided into the aborescent and the solid tumors, probably many of the solid tumors were previously of the branching, wavy variety. The solid tumors are of two types widespread papillary epithelioma, and low, flat, infiltrating carcinoma. The former has a rolled-out advancing border, the upper surface often being covered with short stubby, papillomatous protrusions, or the top may have sloughed off leaving a flat, ulcerated surface. These tumors are sometimes firm, but are often soft flabby and friable, and can easily be scraped off from the surface of the bladder. The histologic picture usually shows the relation of this tumor to the papilloma, remnants of the central connective tissue axis of altered papillae are common and occasionally rounded ends of fairly normal villi are seen.



with hydrochloric or acetic acid. Aqueous solutions of beet juice reacted in a similar way to acid and alkali.

Poole stated that the color of beets undoubtedly is caused by anthocyanin which changes to yellow under certain conditions, the absorption bands of this yellow pigment being identical in position to carotin.

In this case, the presence of the dye in the urine probably was the result of change in permeability of the kidney from injury by nephritis (scarlet fever), since it had not appeared prior to that time.

#### INDIGOCARMINE FUNCTIONAL TESTS

Wassileff<sup>73</sup> has noted complicating reactions in four of 279 cases of intravenous injection of indigo carmine. Immediately following the injection there were vasomotor reactions. Shortness of breath, difficulty in swallowing, urticarial eruption, cardiac palpitation and a feeling of anxiety were manifested. In one case there was anuria for forty minutes. In the remaining cases, the symptoms disappeared in ten minutes leaving only a feeling of exhaustion. In one case, however, symptoms lasted for eleven hours.

Wassileff concluded that these reactions are not due to the toxicity of the drug, but rather to dilution of the blood which can be brought about by the intravenous injection of any drug. These phenomena are the expression of a reaction of the organism to the introduction of a foreign body.

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<sup>73</sup> Wassileff, I. Komplikationen bei intravenösen Injektionen von Indigokarmin, *Ztschr f Urol* **11** 376, 1927.

is surgical whenever possible since it is incurable and precancerous, having been considered the forerunner of squamous cell carcinoma ]

*Rupture of the Bladder*—Negley<sup>46</sup> reported thirty-four cases of rupture of the bladder. Fourteen cases were of extraperitoneal rupture, four patients died, a mortality of 28.6 per cent. Three of the four patients had been operated on two, three and five days, respectively, after injury. The fourth patient was operated on two hours after injury, but death resulted from torn pelvic blood vessels and cannot be attributed either to operation or vesical rupture. Eliminating this death, the mortality is 21.5 per cent. In the first three cases, there were complications, the patient operated on two days after the injury had stricture and gangrenous cystitis, the one operated on three days after the injury had a fractured pelvis, extravasation of urine and pelvic cellulitis, and the one operated on five days after injury had prostatic obstruction and extravasation of urine. The patients recovering after operation had extravasation with cellulitis, stone in the posterior urethra, fractured pelvis, fractured femur, and stricture of the perineal urethra. In the successful cases, the shortest time between injury and operation was four hours and the longest time thirty-two days. The operative procedure included a cystotomy wound in a clean portion of wall of the bladder, closure of the wound if it was clean and easily accessible, and rubber tissue and iodoform cigaret drainage in the prevesical space, making sure that the bottoms of all possible infected cavities were reached by the drains.

There were twenty cases of intraperitoneal rupture, four patients died, a mortality of 20 per cent. These four were operated on within twenty-four hours, two days, two and a half days, and three days, respectively. The complication in the first case was a torn mesentery with hemorrhage, in the second and third cases, the complications were fractured pelvis and shock, and in the fourth case the complication was puncture of the lung from fractured rib. The patients who recovered had the following complications: fractured pelvis, nine, peritonitis, nine, fracture of the femur in the hip joint, three, torn mesentery, three, ruptured intestines two and fractured skull, one. Operation included opening of the peritoneal cavity, mopping up or aspirating all the free fluid which was within easy access, rubber tissue drain through the lower angle of peritoneal opening, cystotomy wound in clean portion of bladder, suture of wound only when it was clean and easily accessible and drainage of bladder with a catheter or tube. In the cases in which the patients recovered the longest time between injury and operation was five days; in all the others it was twenty-four hours or less.

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46 Negley I. C. Rupture of the Bladder. *J. Urol.* 18: 307, 1927.

In reviewing our previous series, we found that deaths from burns of similar extent and severity for which treatment by picric acid and dry air was being given, were approximately 40 per cent and deaths due to debridement resulted in a mortality of 57 per cent. These figures show a definite decrease in mortality attributable to treatment by tannic acid.

The table gives the mortality in cases of burns.

#### IMMEDIATE TREATMENT FOR BURNS

On arrival at the hospital, the patient is treated for the immediate shock. Morphine is administered, and either a hypodermoclysis or a transfusion is given as soon as possible. The skin is cleansed as far as can be done without creating any greater shock. The skin covering the blisters is removed, and dressings saturated with a 5 per cent aqueous

*Mortality Rates in 114 Cases of Burns*

Decades	1	2	3	4	5	6	7	Total
Deaths occurring in 148 hours (shock)	5	2		2†	1	0	1	11
Deaths from toxemia and infection	3	2	2	3				10
Deaths probably attributable to other causes			1‡		1§			2
Number of cases	8	4	3	5	2	0	1	
Percentage	34*	17	13	21	8	0	4	
Deaths								23
Percentage mortality								20.1
Percentage mortality due to shock								10
Percentage mortality due to toxemia and infection								10.1

\* Note the high mortality in the first decade.

† Patient also had fractured skull (1 case).

‡ Lobar pneumonia and suppurative pleurisy.

§ Lobar pneumonia and acute nephritis.

solution of tannic acid are applied. These dressings are applied loosely and kept saturated with the solution for twenty-four hours or until the burned area is tanned a mahogany brown. Other authorities have advised using a spray of tannic acid, without the application of dressings. We have preferred the loose application of gauze saturated with tannic acid. No bandages or constricting apparatus are applied. When the burned area is sufficiently tanned all dressings are removed, and a tent is made to prevent pressure of the bed-clothes. Warm air is created by inserting electric lights. Care should be taken to keep sterile pads or sheets beneath the burned areas that rest on the bed. Infection can, and frequently does, occur beneath the tanned area (fig. 4). Every effort should be made to prevent its inception.

We have found that patients with burns need constant care and badly burned patients should have a special nurse. The burnt areas must be kept scrupulously clean and the patient's position must be constantly changed. Forcing the fluids is important as it diminishes the

hematuria. He had severe bronchitis, and was anemic and cachectic; there was 200 cc of residual bloody urine. Cystoscopic examination revealed marked cystitis and evidence of a malignant tumor in the region of the sphincter. Cystotomy was performed and afforded some relief. A short time afterward, difficulty of urination and dehydration became marked, and the patient died. A diagnosis was made of rupture of the bladder through the malignant area. Necropsy showed diffuse peritonitis. Perforation was found on the upper posterior wall. Musculature was not seen at the site of rupture, nor was there any carcinomatous tissue in this region, the area being replaced by inflammatory connective tissue.

Bitschaj stated that while tuberculosis and tumor cause destruction of the vesical wall, in this case the hydrodynamic factors were probably the cause. The tumor caused a valvelike formation leading to the rupture of the atrophied and malnourished vesical wall.

*Vesicovaginal Fistula*—Young<sup>53</sup> described a transvesical operation for the repair of vesicovaginal fistula. In one case, eleven operative attempts were made to repair the fistula before it was accomplished by Young. The operation consisted of suprapubic cystostomy, excision of the vesicovaginal fistula from the bladder into the vagina with the assistance of special instruments, resection of the vesical bridge and closure of the fistula in three layers. The first layer was closed by a purse string suture of heavy chromic catgut to approximate the vaginal mucous membrane. A finger was inserted in the vagina and pressure made on the anterior vaginal wall to elevate the vaginal end of the fistulous tract and to expose the mucous membrane. By this means, it was possible to insert the needle parallel to the vaginal wall through the submucosa without penetrating the mucous membrane. The second suture was a purse-string of plain catgut to approximate the vesical muscle. The third was a continuous through-and-through plain catgut suture approximating the vesical mucosa, submucosa and adjacent muscle. The suprapubic wound was drained, the Pezzer catheter being left in place for three weeks. The patient was placed on her abdomen for ten days, after which she was turned on her back. One month after operation, she was dismissed cured.

Young has devised an instrument to aid in elevating the fistulous tract into the bladder, the instrument is similar to his prostatectomy tractor but has delicate nonfenestrated blades. It is introduced into the fistulous tract with the blades closed, then opened and traction made while the tract is dissected out.

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53 Young, H. H. Repair of Vesicovaginal Fistula, Presentation of a New Instrument, *Surg. Gynec. Obst.* 45:226, 1927.

toxemia and aids the kidneys. Normal and hypertonic saline administered by hypodermoclysis does much to relieve toxemia and prevent vomiting. Davidson has shown that there is a sodium chloride retention similar to that described by Haden and Orr,<sup>1</sup> and for this reason the use of hypertonic saline may be of great value.

#### INFECTION BENEATH THE TANNED MEMBRANE

In a typical case of first or second degree burn, after a period of one to two weeks the tanned membrane begins to curl at the edges, and

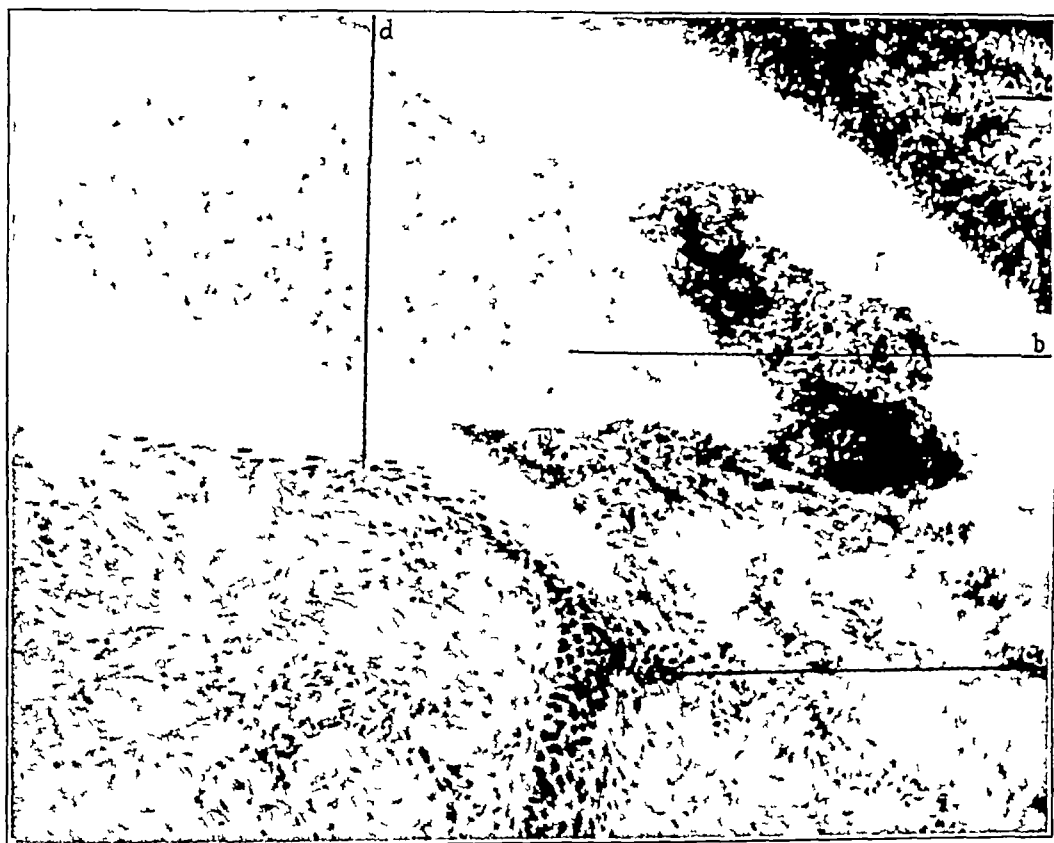


Fig 3—High powered view of figure 1. *a* indicates the tanned membrane, *b*, the separation zone, *c*, the hair follicle, *d*, the beginning epithelization arising from the hair follicle, while the tannic acid is in situ.

it is seen that epithelization has already been initiated. If infection is not present the membrane gradually separates, leaving beneath it newly formed epithelium and granulating areas of relatively small extent, dotted here and there with islands of epithelium (fig 5).

1 Haden and Orr. Intestinal Obstruction and Gas Bacillus Infection. *Surg Gynec. Obst.* **37** 465 (Oct) 1923, *J. Exper. Med.* **37** 365 (March) 1923, *Bull. Johns Hopkins Hosp.* **34** 26 1923.

membrane, such a lobe could be immediately pinched off from its pedicle without further manipulation

In perineal prostatectomy, the same rules hold true in regard to separate or total adenectomy. During the perineal operation, one should not fail to look for, recognize and remove coexisting subcervical hypertrophic tissue, remembering that it would not be removed from within the capsule and often lies as an intravesical projection free of any attachment to other hypertrophied gland tissue.

As the normal histology presents two masses of gland tissue lying in the median line and presenting so-called middle lobes when hypertrophied, but having separate origin and separate anatomic significance, in the future the term "middle lobe" should be left out and such growths should be spoken of as arising either from hypertrophy of the posterior prostatic commissure or from hypertrophy of the subcervical gland.

[ED NOTE—Beer, in discussing Randall's paper, felt that Randall was not entirely sure of middle lobes and commissural hypertrophies, and he himself favored the term "middle lobe." Since there are two commissures at the vesical neck, it only tended to complicate matters. Albarran glandular hypertrophy as a clinical entity is rare, Beer believed it to be less than 2 per cent. Dismissing this type, he felt that his experience had been similar to Randall's, that Zuckerkandl and Tandler were right in their studies that all adenomatous masses developed anterior to the ejaculatory ducts although not always from the middle lobe, and that they were often lateral in origin as well as in the floor of the posterior urethra above the verumontanum. The posterior lobe becomes compressed against the capsule as adenoma develops in the middle and lateral lobes. Beer felt that it is not so important to know what is to be encountered surgically, yet the picture should be accurate if the approach is perineal, extensive study is not essential for the suprapubic operation, although cystoscopy is usually performed in all cases. The important point to remember from this presentation is that in postmortem studies the commissural adenomas or adenomas of the middle lobe begin much earlier than do those in the lateral lobe, in the sixth decade, the two combined become the typical picture of prostatic obstruction.]

Lowsley felt that Randall's paper is a distinct contribution, and he agreed with all the statements. He believed that hypertrophy may begin in any one of the four sections of the prostate, everybody feels certain that it does not occur in the posterior lobe. Lowsley felt that Beer was wrong as to the lack of subcervical gland enlargement. He had found that in 23 per cent of men over 30 years there was more or less enlargement of the subcervical gland. When this growth is small, the patients may wander from physician to physician because of inability to recognize the true condition. They will be found to have subcervical enlargement,

In the third degree type of burns, the membrane is lifted by the serum after a while and has to be removed. Treatment of the granulating surface then presents the same problem as in any third degree burn with any type of treatment. There are a certain number of patients who have an elevation of temperature from 102 to 103 F, which con-



Fig 5—Artist's sketch showing the islands of epithelium in the midst of the granulating area following (a) tannic acid treatment, (b) 1 to 5,000 acriflavine as a wet dressing for the granulating area following the separation of the tanned area

tinues for a week or ten days, eventually they succumb if the infection is not treated. The pulse is not extremely rapid but of low tension. They do not seem seriously ill. They often suffer from gastro-intestinal

Randall, in closing, stated that he used the term "middle lobe" by force of habit, but really meant commissural hypertrophy. He agreed with Lowsley that subcervical hypertrophy was not infrequent, from his statistics it formed 30 per cent of the cases of hypertrophy when occurring alone, combined with bilateral enlargement, the percentage was immediately augmented. Randall wished to emphasize the choice of operation according to type of hypertrophy. He was convinced that definite preoperative pictures could be diagnosed from the clinical, cystoscopic and rectal examinations, which would place each prostatic case in a definite group and would classify it as to the type of hypertrophy, for instance, in the case of sudden complete retention, in which catheter drainage will tide over the acute phase, voluntary urination being reestablished on removal of the catheter and little, if any, residual urine being revealed. In this type there is only bilateral extravescical lobe hypertrophy, which can be proved by both rectal and cystoscopic examination, while at operation two separate lobes will be found and should be separately enucleated. In the second type the patient is in fair health, but when examined a large amount of residual urine is found which preliminary treatment will not influence. In all probability, rectal and cystoscopic examination would reveal the enlargement of the lateral lobe and the hypertrophy in the posterior commissure. The hypertrophied mass should be removed whole and should include both lateral lobes attached to one another by the hypertrophic commissural tissue. In either of these types can suprapubic or perineal prostatectomy be successfully performed, although Randall preferred removal of the commissural enlargements suprapubically and the simple bilateral one perineally. When the subcervical glands become hypertrophied, the best approach is suprapubically because of the anatomic origin of the enlargement and the fact that such lobes are always intrasphincteric as well as intravesical. Randall believed that these are refinements of diagnosis and operative technic which although they are not essential have a decided influence on conservative surgery, minimizing injury, offsetting hemorrhage and giving greater assurance of permanency of cure.

*Prostatectomy*—Thomson-Walker<sup>55</sup> believed that the time has come when prostatectomy should do more than save the life of the patient, that it is now necessary to go further and insure functional success as well. Thomson-Walker's mortality in 156 consecutive cases is 4.4 per cent. He believed that causes of failures may be reduced to two fundamental factors, sepsis and obstruction. The belief that all urinary disorders are septic is erroneous and is the result of unsatis-

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<sup>55</sup> Thomson-Walker, John. Failures of Prostatectomy. *Lancet* **212** 1009 1927.



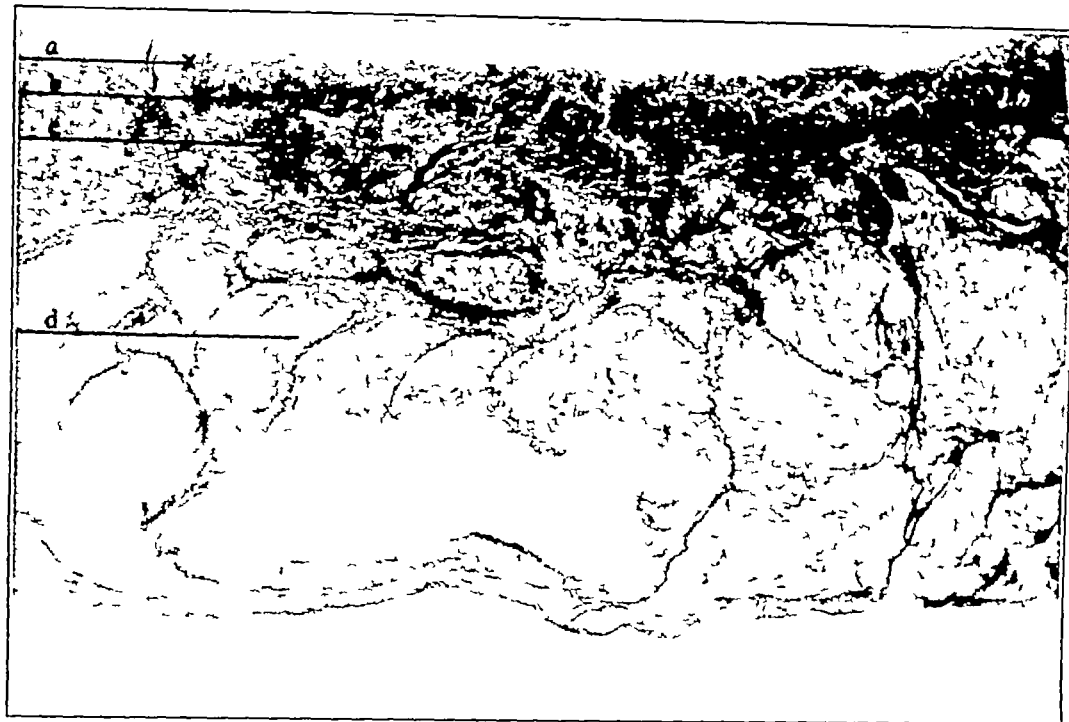


Fig 7 (case 1) —Low powered view of the tissue debris six days after the burn *a* indicates necrotic tissue, *b*, the separation zone, *c*, the living connective tissue and *d*, the fat (From Ann Surg, July, 1926 )

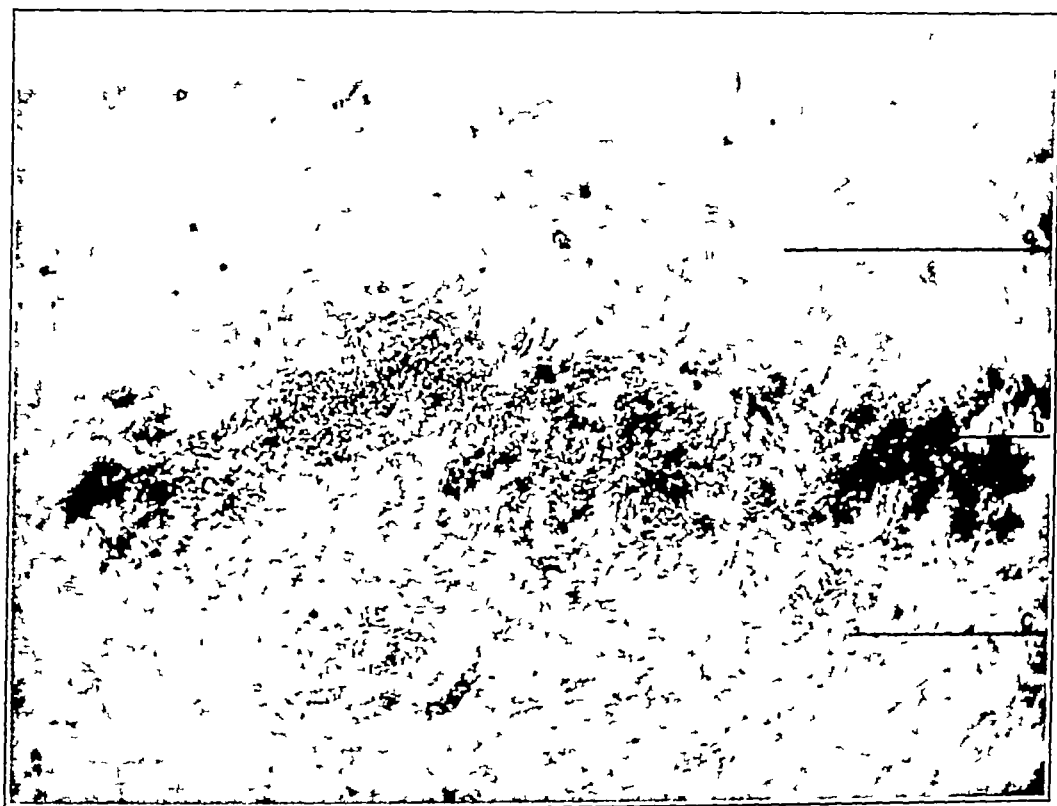


Fig 8 (case 1) —High powered view of the separation zone *a* indicates necrosed tissue on the surfaces, *b* the separation zone *c* the connective tissue showing the presence of infection (From Ann Surg July 1926 )

or could be catheterized with difficulty or not at all. He considers the two stage operation an attempt to repair the mistakes of earlier neglect or unskilful treatment. Following prostatectomy, all tags, folds of bladder mucous membrane and semidetached plaques of capsule or nodules of prostate are removed. A hemostatic stitch is introduced on each side of the neck of the cavity, and a continuous suture of fine catgut is put in from the right side around the posterior edge and finished on the left side. If necessary, the capsule is packed with iodoform gauze. [Thomson-Walker believed that several factors contribute to the formation of sepsis, one is finger enucleation by rectum.]

Lower<sup>56</sup> stated that operation on the bladder in which drainage must be instituted is never an ideal procedure. For many years, he has closed the bladder after the removal of stones or tumors and has maintained drainage by means of a urethral catheter. Recently he has applied this complete closure following prostatectomy. He has adopted a method whereby the bleeding is entirely controlled by suture, and has discarded the use of packing or of any kind of a distensible bag. He has employed this method in a series of fifty cases, in most of which the bladder was closed at the time of operation. In a few instances, a rubber tube was inserted suprapubically for a few days. A catheter is passed through the urethra. With a dot-and-dash stitch, a suture is then passed from the bottom of the cavity from which the prostate has been removed, along the wall of the cavity up through and including a small margin of the mucous membrane of the bladder. The needle is then removed and rethreaded on the other end of the suture, and the same procedure is carried out on the opposite side. With this suture the walls of the cavity are brought in apposition, snugly but not tightly, and the catgut is cut short. Catgut no 0, or not heavier than no 1, is used. The suture is inserted below the catheter, and as many more are applied as may be necessary to close the cavity. All the tag ends of the mucous membrane are trimmed off so that a good approximation can be made, thus facilitating healing and preventing the possibility of a tag dropping into the urethra and causing obstruction. One fine catgut suture is then passed through the catheter to hold it in position.

Since Lower has employed this method of controlling hemorrhage and completely closing the bladder he has found that the period of convalescence is shortened, that postoperative care is lessened, and that the incidence of suprapubic fistula is reduced to a minimum.

Chute, in commenting on Lower's method of bladder closure, said he believed that Lower's success is due to his operative skill, but that

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<sup>56</sup> Lower W E. Complete Closure of the Bladder Following Prostatectomy. Preliminary Report, I A M A 89 749 (Sept 3) 1927

In children with burns of the extremities we believe that primary attention should be given to the granulating surfaces, and that if contractures tend to occur, daily gentle manual extension by both physician and nurse is preferable to any retention apparatus. After the skin is reformed, an apparatus or operation may be easily devised to overcome the contractures. The following two cases illustrate these factors.

#### REPORT OF CASES

CASE 1—V. K., a girl, aged 10, was admitted to the Lincoln Hospital on Jan. 1, 1925, with second and third degree burns caused by hot water over the

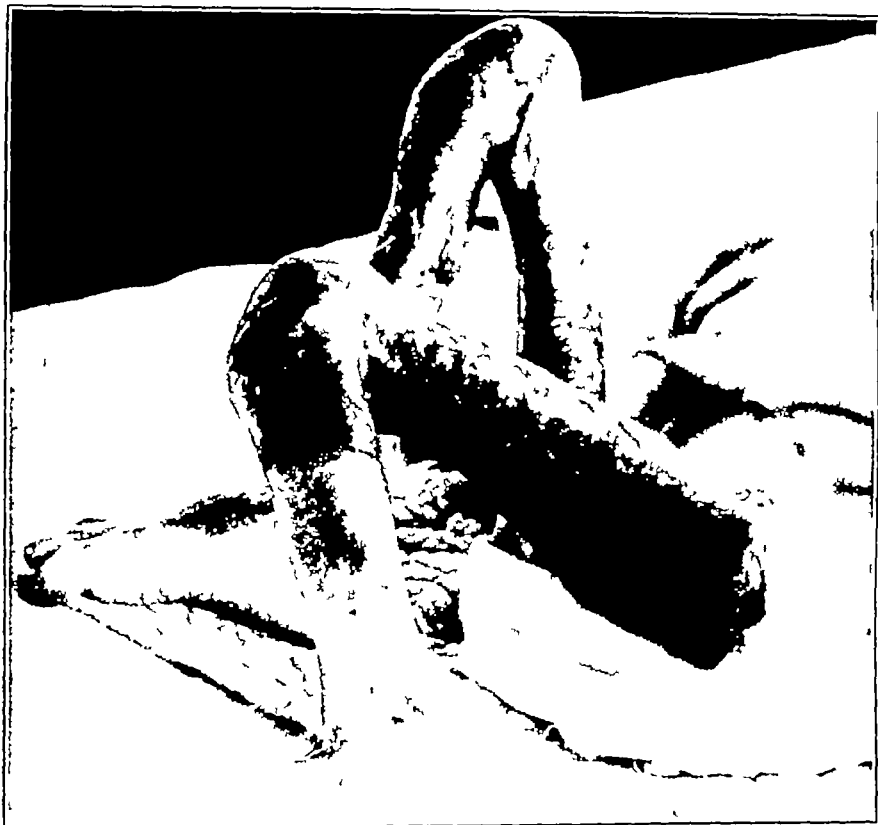


Fig. 10 (case 2) —Patient four months after admission to the hospital. Note the emaciation of the patient with contractures of the knee joints, swelling and edema of the feet. Figures 14, 15, 16, 17, 18, 19 and 20 are microscopic views of the tissue beneath the granulating areas.

buttocks, thighs, legs, feet and left hand. At this time we had not adopted the treatment with tannic acid. On the sixth day she was intensely toxic and so ill that we doubted that she would live twenty-four hours. Under light anesthesia, the typical pigskin burned area on both thighs was excised down to the fascia (figs. 7, 8 and 9). Wet dressings were then immediately applied. This was followed by a blood transfusion of 250 cc. The next day her condition was markedly improved, and the signs of toxemia gradually disappeared. While she was in the hospital she received six transfusions and at least ten operations.

The close association of the development of epididymitis shortly after urination in cases of prostatectomy causes one to suspect a possible focus of infection in the seminal vesicles, as suggested by Boyd and Morson. In all probability, this is secondary to the existing cystitis. In view of the fact that the operative procedure is only increased by from five to ten minutes with the probability of no complicating epididymitis, it appears that the procedure might be rational. Complicating epididymitis in old men who are frequently debilitated and whose resistance is lowered not only delays convalescence but is discouraging to the patient. Sometimes, in the presence of complications incision and drainage is necessary. In the one case in which epididymitis developed after ligation and section, it occurred five weeks after operation and two weeks after the patient had returned to his home.

Lazarus<sup>58</sup> found that roentgen-ray treatment is distinctly useful in selected cases of hypertrophy of the prostate and prostatitis.

Urinary obstruction in adenoma of the prostate depends to a large extent on the degree of edema of the mucosa of the prostatic urethra. This same congestion and edema of the mucous membrane are significant in prostatitis. The application of the roentgen ray is also often a valuable palliative measure in the treatment of these conditions. Its good effects are dependent on the ability of such irradiation to reduce congestion. Roentgen rays will not sterilize an infected prostatic focus and do not reduce the size of the prostatic tumor.

Davis<sup>59</sup> asserted that the mortality from prostatectomy (properly performed) compares favorably with that of the lesser of the major surgical procedures, and that prostatectomy may therefore be classified among the safe operations. Davis' report includes 107 consecutive cases of perineal prostatectomy with only one death, a mortality rate of less than 1 per cent. While this is a good record, it is not particularly unusual, since larger consecutive series, with lower mortality rates, have been reported by others. Cecil has reported 100 consecutive cases with a mortality of 2 per cent, and Hinman a series of eighty-one operations without a death. Hunt's recent report includes 204 cases with only three deaths, while Young has reported several large series, his largest published number of consecutive cases without a death being 198. Therefore, since large series of cases of prostatectomy, with surprisingly low mortality rates have been reported by different operators, it is clear that such results may be consistently accomplished by careful effort.

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58 Lazarus, I. A. Deep Roentgen Therapy in Disease of the Prostate Gland, *J Urol* **17** 37, 1927.

59 Davis, Edwin. Perineal Prostatectomy Under Sacral Anesthesia. One Hundred and Seven Consecutive Cases with One Death. *J A M A* **88** 784 (March 12) 1927.

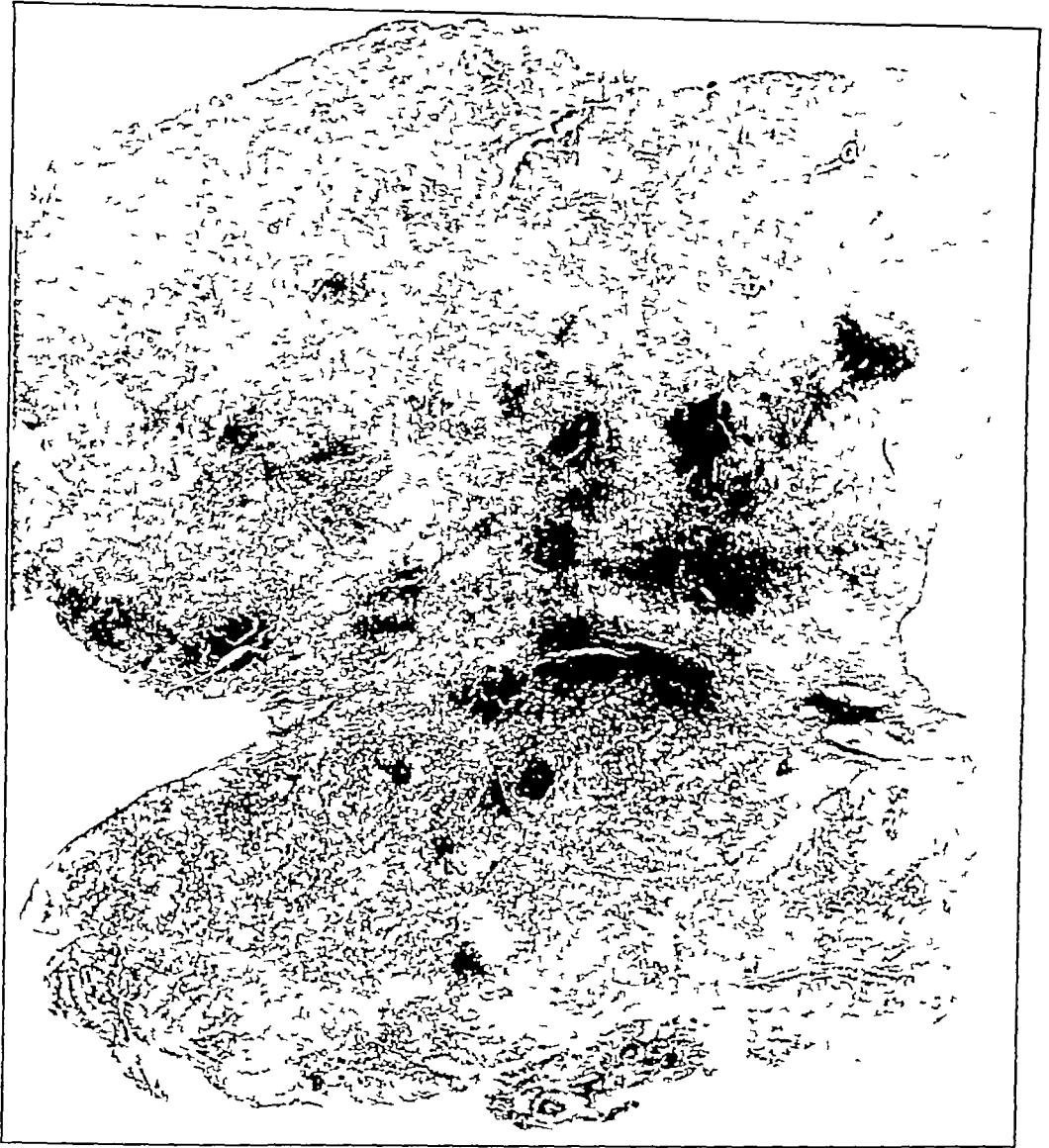


Fig 13—Low powered view of the tissues removed by debridement in case 2 *a* indicates the superficial granulating area (fig 14), *b*, the junction of the granulating area with the scar tissue (figs 15, 16 and 17), *d*, the deep fat with infiltration of leukocytes and round cells about the vessel (fig 18) and *c*, infiltration of fat extending down as far as the fascia lata with large cells retaining one or more nuclei (figs 19 and 20)

In cases of suprapubic prostatectomy, there was no difference in the late results following the different types of anesthesia. Sacral anesthesia does not entirely eliminate the possibility of respiratory infection, which, when it occurs following the administration of ether, is usually attributed to pulmonary irritation from the anesthetic. Sacral anesthesia definitely eliminates the group of immediate deaths usually attributed to shock and cardiac disease. The earliest death in the series of 270 cases occurred on the fifth day and followed postoperative hemorrhage and urinary infection, one death on the eighth day was due to uremia, and the remaining seven deaths, in the cases in which sacral anesthesia was employed, occurred from thirteen to forty days postoperatively, but in no case was there a definite causal relationship between the sacral anesthesia and death.

In either the perineal or the suprapubic operation, the most important factors are the preliminary preparation and complete surgical hemostasis, the method of surgical approach is of less importance.

*Cases from the Mayo Clinic*

	Cases	Percentage	Hospital Mortality	
			Cases	Percentage
Sacral	270	51.33	9	3.33
Spinal	187	35.55	13	6.95
Ether	69	13.12	5	7.24
Total	526		27	

Thomson-Walker<sup>60</sup> reported a case of recurrence of enlarged prostate after prostatectomy. The first operation was performed in 1916. The patient's convalescence was uneventful, and he remained free from pain for eight years, when epididymitis with frequent micturition and difficulty occurred. When rectal examination was made, the swelling felt like an ordinary, moderate sized enlargement of the prostate gland. There was obstruction to a catheter at the internal meatus.

Ten years after the first operation, Thomson-Walker opened the bladder and found a prostatic nodule about the "size of a cherry" projecting into the bladder at the posterior lip of the internal meatus. Partly by dissection and partly by enucleation, a structure similar to an enlarged prostate gland was removed, and the patient was treated as for ordinary open prostatectomy. The specimen, viewed from the posterior aspect, resembled the enucleated specimen of an ordinary enlarged prostate. Seen from the anterior aspect the ring at the internal meatus was complete, but below this the ring was incomplete, and there was a wide tunnel representing the prostatic urethra, which would admit

<sup>60</sup> Thomson-Walker, John. Recurrence of Enlarged Prostate After Prostatectomy, *Proc Roy Soc Med, Sect Urol* 20:20, 1927.

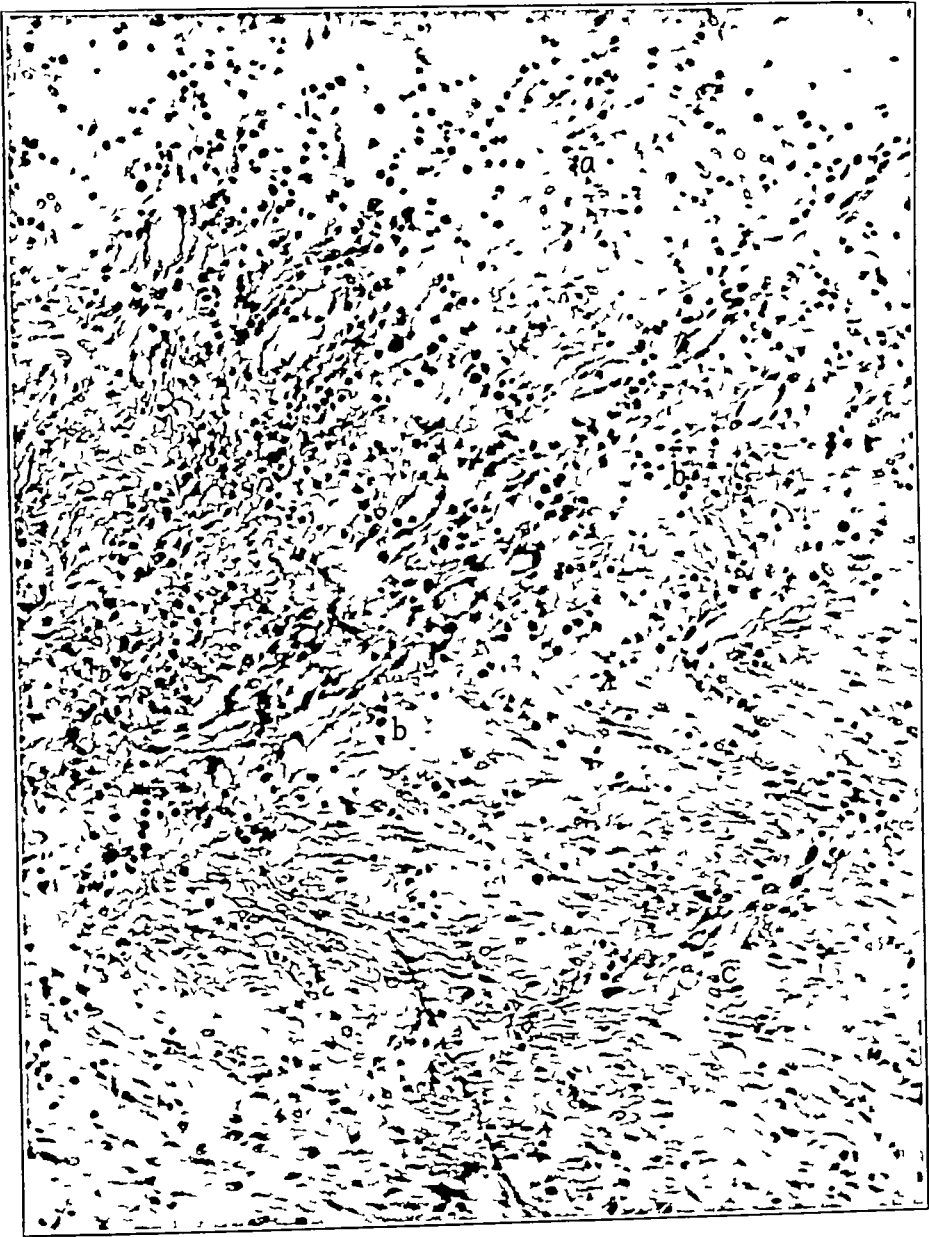


Fig 15 (case 2) —High powered view of the junction of granulation and scar tissue *a* indicates the superficial granulation tissue, *b*, the junction of the scar and granulation tissue, *c*, the scar tissue. It is obvious that if a curet were used in this case the granulation would be removed to (*b*), leaving a dense scar tissue base

catheterized. Convalescence was uneventful. Pathologic examination of the removed tissue showed tubercles just beneath the mucous membrane. Careful study of the kidney revealed closed right pyonephrosis, in all probability tuberculous, which in turn had infected the urethra.

Wiedhopf believed that the rarity of this condition in women is due to the fact that only urine passes through the urethra, in men the frequently infected genital secretions also pass. The shortness of the urethra in women may also be a factor. The infection is usually from the kidney or peripheral urinary tract rather than from such a condition as lupus of the vulva.

*Tumors*—Schmidt<sup>63</sup> found only seventeen cases of sarcoma of the female urethra in the literature. He described a case of tumor in the urethral wall about 2 cm in diameter. This type of sarcoma, which originates in the musculature of the urethra and includes the adjacent connective tissue and vessels, extends in the loose periurethral connective tissue anteriorly to the meatus. Following destruction of the musculature, the urethral lumen is invaded. The treatment of urethral sarcoma is operative. It may be removed, as in Schmidt's case, with the Paquelin cautery. Wide resection is not necessary, since the post-operative prophylactic use of the roentgen ray is productive of good results.

[Ed. NOTE—Sarcomas similar to connective tissue tumors in other parts of the body are most common in young persons. They may be pedunculated, and in the female often protrude from the urethra. They grow rapidly, metastasize extensively, and the prognosis is poor. Mariachess<sup>64</sup> reported a case of a man, aged 22, in whose penis was a mass which increased rapidly in size, four months after the onset, the growth caused complete obstruction. Mark<sup>65</sup> observed a case in a man, aged 24. The growth was in the anterior urethra and caused severe dysuria and terminal hematuria. Several months later, the whole urethra was involved. Kaufmann<sup>66</sup> reported a case of spindle cell sarcoma occurring in a man, aged 55. Albrecht<sup>67</sup> reported a case of pigmented sarcoma in a man, the condition was discovered at necropsy.

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63 Schmidt, H. R. Spindelzellensarkom der weiblichen Urethra, Zentralbl f Gynäk **1** 3122, 1926, abstr Ztschr f Urol **21** 390, 1927

64 Mariachess, J. Sarcome de l'uretere. Émasculation totale, Ann d mal Org Gen-Urin **16** 886, 1898

65 Mark, E. G. Primary Sarcoma of the Male Urethra, Report of a Case, Tr Am Urol A **5** 59 and 73, 1911

66 Kaufmann, C. Verletzungen und Krankheiten der männlichen Harnrohre und des Penis, F Enke, 1886, p 331

67 Albrecht, H. Ein Naevus papillaris pigmentosus der Pars prostatica der Urethra mit sarko-karzinomatösen Metastasen, Verhandl d deutsch path Gesellsch **14** 253, 1910



were performed for skin grafting, pinch grafts being used. She developed moderate contractures of both knees, and after the area was entirely epithelized she was repeatedly taken to the operating room and her legs partially straightened under anesthesia. If the skin tore in the popliteal space, the area was immediately grafted and retentive apparatus applied. This operative procedure was repeated several times, until the contractures were corrected. She is now well, and the flexion and extension in both knee joints is perfect (fig 6).

CASE 2—T. T., a boy, aged 3 years, was admitted to the Lincoln Hospital on Nov 14, 1925. He was extensively burned from the abdomen to 1 inch above the ankle joint. Tannic acid dressings were applied. As the burns were of the third degree type, the membrane gradually separated, leaving extensive granulating surfaces. As he was developing contractures of both knees, it was thought advisable to attempt a Bryant overhead traction, suspending him by stirrups about the feet. Almost immediately he developed pressure sores over the os calcis and the anterior surface of the foot, with resultant edema of the foot and toes (fig 10). In an attempt to treat the patient for the edema of the foot, grafting of skin on the granulating areas of the thighs was delayed for a long period. Our earliest attempts at grafting skin were failures, although the surfaces had been thoroughly curetted. We then decided that the failure was due to the formation of scar tissue beneath the granulating tissue. Therefore, by sharp dissection, the scar and granulation tissue down to his fascia lata was excised, and skin was immediately grafted on the area. This was followed by success. During the period of two years this child has been subjected to about fifteen operations for skin grafting and numerous transfusions (figs 11 and 12).

In children with extensive burns who have not much normal skin that can be used for grafts, we have found that pinch grafts can be inserted about 1 cm from each other, and that epithelization will occur from each graft, bridging the defect. It is better to attempt small areas at a time, repeated operations being performed. The extremity should be immobilized and dressings so applied that there will be no movement of the grafts, and sufficient pressure must be used to prevent the accumulation of serum beneath them. On the other hand, as has been emphasized by Davis, the pressure should not be great enough to interfere with the capillary circulation, so that the grafts may receive their blood supply. We have found it advisable always to excise the scar tissue near the advancing edge of epithelium, because if grafts are planted in the center of the granulating surface, they are gradually choked off by the surrounding exuberant granulating tissues. (Figures 13, 14, 15, 16, 17, 18, 19 and 20 show clearly the pathologic condition in this case.) A curet would have merely scraped off the superficial granulating area and left behind the dense scar tissue base. At one time, the contractures about the knee joints in case 2 were alarming, but by numerous moderate stretchings, with immediate grafting of the rents in the popliteal space and the application of splints to maintain the improved positions the patient can now completely extend one leg and there is a contracture of only about 30 degrees of complete extension of the other. If we had originally treated the granulating areas to prevent

These tumors have caused the following symptoms pain in the middle and lower part of the abdomen and, when the bladder was involved, dysuria, polyuria and hematuria. Four patients discovered lumps in the abdominal wall before they experienced any trouble from them. Nuboer's case was unique in that his patient complained of pain in the left arm and due to distant metastasis before the primary growth had been noticed or had given any symptoms.

Eighteen of the reported cases were malignant, two were benign. In nineteen cases, the growths arose primarily in the urachus. In one case, a primary papillary adenocarcinoma of the bladder extended to, and secondarily involved, the urachus which was patent. In fourteen of the eighteen cases, the bladder had already been invaded by the growth when the patient consulted a physician. Whenever this had occurred, there was a broad band of induration extending from the lower pole of the tumor to the vertex of the bladder at the point where the median abdominal ligament (the remains of the urachus) joins that organ. In six instances only were the outer coats of the bladder involved, in eight, cystoscopic examination showed carcinomatous masses projecting from the vertex into the cavity of the bladder.

In only four cases of malignant urachal tumors was the peritoneal cavity found to have been invaded by the growth. Radical operation was performed in twelve of the malignant cases. In seven cases in which radical excision of the malignant tumor was carried out the vertex of the bladder was removed. Eight patients recovered satisfactorily.

Brady's study of malignant urachal tumors has impressed him with the fact that these growths occur more frequently than had previously been supposed, and that in order to expect cure radical operation must be performed, usually including removal of the vertex of the bladder and portions of the anterior abdominal wall.

[ED NOTE—It is difficult to distinguish definitely between tumors of the umbilicus and those of the upper portion of the urachal tube, a similar difficulty is encountered in differentiating tumors of the lower urachus and those originating in the dome of the bladder. Barringer reported an unusual adenocarcinoma involving only the apex of the bladder, the larger part of the tumor was above the bladder. Ewing, who examined the tumor, said that the growth was unique and probably came from a remnant of the allantoic end of the bladder, or possibly from a cloacal inclusion. The urachus ordinarily becomes obliterated at about the third month of fetal life. It becomes obliterated irregularly so that at times, segments occur in which the lumen persists. Rankin stated that these unobliterated segments form cavities that may later give rise to the urachal cysts which are seen clinically. The lining of the urachal tube is composed of one or more layers of transitional epithelium, much like the mucous membrane of the bladder.]



Fig 18 (case 2) —High powered view of fat showing (a) large cells with clear cytoplasm infiltration of fat, and b, perivascular infiltration of leukocytes and c fascia lata

## URINARY INFECTION

Ball <sup>71</sup> believed that adhesion and anatomic proximity of inflammatory lesions of the intestinal tract and the pelvic viscera are responsible for many cases of urinary infection. In reviewing a series of cases, he found that in almost every instance it was the onset of an acute flare-up of an intestinal or pelvic lesion during the course of chronic urinary infection that led to the discovery of the actual cause of the trouble.

Adhesion of a chronic lesion, or obstruction caused by an acute lesion of the alimentary tract or pelvic viscera, to the ureter, may be of such a nature that, although not obliterating the lumen of the latter, it may act in such a manner as to cause dilatation of the renal pelvis and congestion of the renal cortex, and thus provide a condition amenable to the persistence or recurrence of an infection. Ball does not intend to suggest that direct contact of the urinary passages with infective lesions of the adjacent structures is the only channel through which these infections take place, but he hopes rather to stimulate investigations in this direction with a view to explaining some of the cases of urinary infection for which the explanations now in use are inadequate.

## URINARY PIGMENTATION

Poole <sup>72</sup> reported an unusual condition of pigmentation of the urine following the ingestion of red beets (*beta vulgaris*) and which might readily be confused with other more serious conditions in which red pigment appears in the urine. A boy, aged 6, was admitted to hospital because of periodic reddish discoloration of the urine, failure to gain weight and attacks of abdominal pain. He had had scarlet fever with complicating nephritis. On five occasions following this, reddish urine was noted and the patient never seemed well. Each time he was thought to have had nephritis he had been put on a milk diet, and the red color had disappeared. General examination revealed a malnourished child with choreiform movements, a loud systolic heart murmur and secondary anemia. The urine was deep red but there was no blood pus or other abnormal constituents. Spectroscopic examination did not show blood pigment and an acid solution did not show the characteristic bands of hematoporphyrin. Beets were removed from the child's diet and the urine became clear. On the addition of beets to the diet the phenomenon could be reproduced.

The red color of the urine changed to deep yellow on the addition of alkali such as potassium hydroxide and returned on acidification.

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71 Ball W G. Some Anatomical Factors in Urinary Infections. *Proc Roy Soc Med, Sect Urol* 20:1 1927.

72 Poole M W. Anthocyaninuria. *Am J Dis Child* 33:784 (May) 1927.



Fig 20—High power view of fat showing infiltration with large polymorphonuclear and mononuclear cells with clear cytoplasm. It is obvious from these illustrations that infection extended well below any surface that could be reached by local antiseptics.

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## LATE TREATMENT OF BURNS

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AND

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In a previous communication we discussed the immediate treatment for cutaneous burns. We concluded that treatment with tannic acid excelled other known methods, for the following reasons: (1) It diminishes pain, (2) it prevents fluid depletion, (3) it decreases toxæmia, and (4) in first and second degree burns, it allows epithelization to proceed while the membrane is in place.

This splinting of the granulation tissue by the rigid tannic acid membrane while epithelization is in progress seems to prevent contractions of the scar tissue (figs. 1, 2 and 3).

During the past two years, we have had the opportunity to treat several patients with severe burns and we have learned some aids in late treatment which may be of value. We wish to review briefly the early treatment of burns by tannic acid and then to discuss the following factors that occur after the primary treatment: (1) infection beneath the tanned membrane, (2) treatment of the granulating surfaces and (3) the causes of failure in attempts to graft skin on the granulating surfaces.

One hundred and fourteen patients with burns were treated with tannic acid at the Lincoln Hospital from Jan. 1, 1926 to Sept. 1, 1927. Twenty-three died, a total mortality of approximately 20 per cent. The cause of death as analyzed depended on the age of the patient, the extent of the body area involved and the complications which may have arisen. The ages varied from 9 months to 61 years. The length of hospitalization varied from two hours to seventy days. We have attributed the deaths occurring within forty-eight hours to shock. The deaths occurring after this period we have classified as deaths due to infection and toxæmia. Among the complications in this group were parturition (two cases), poisoning from illuminating gas (condition present on admission), chronic pulmonary tuberculosis, acute nephritis, fracture of the skull and mandible and fracture of the pelvis with multiple lacerated wounds of the scalp (one case each). In this series eleven patients died of shock, or approximately 10 per cent, and twelve died of toxæmia and sepsis, a mortality of approximately 10.4 per cent.

# METASTATIC OPHTHALMIA

SUBACUTE ENDOCARDITIS COMPLICATED BY METASTATIC OPHTHALMIA  
AND MENINGITIS, DISTRIBUTION OF GENTIAN VIOLET SOLUTION  
SIX AND ONE-HALF HOURS AFTER INJECTION  
INTO CISTERNA MAGNA REPORT OF A CASE \*

FRANK H. RODIN, M.D.

SAN FRANCISCO

Metastatic ophthalmia usually means an inflammation of the eyeball, resulting from some endogenous infection. This inflammation takes place through an embolus, septic material from some focus of suppuration enters the circulation and becomes lodged in the choroidal vessels. The cases vary, the infection may be mild, a small degree of sight being retained, or, as in cases of severe infection, the condition may resemble panophthalmitis. One or both eyes may be affected. According to Fuchs,<sup>1</sup> in rare instances, this condition may occur in acute infectious diseases, such as typhus and typhoid fever, variola, scarlet fever, anthrax, influenza, ulcerative endocarditis, diphtheria, erysipelas, pneumonia and Weil's disease. Metastatic ophthalmia is produced either by ordinary germs, among which the streptococci rank first and the pneumococci second, or by bacteria which are specific for certain definite diseases (e.g., the meningococcus, the pneumobacillus, the influenza bacillus, the typhoid bacillus or other bacteria). A mixed infection may also occur.

## REPORT OF CASE

*History*—F. W., a man, aged 63, was first seen at the Stanford University Eye Clinic on March 31, 1926. Five years before coming to the clinic, he had been struck in the right eye with an iron pipe and a foreign body had been removed from the cornea. Since then the eye had become inflamed a number of times, the inflammation lasting a week. He was not sure whether the vision was impaired following the inflammations. The present complaint was that his right eye had felt "sandy" and painful for two days, and that he was unable to see with it.

*Examination*—The patient could see fingers at a distance of 10 feet (304.8 cm.) with his right eye, glasses did not improve the sight. With his left eye he could perceive movement of the hand, with a -5.0 spherical lens, this vision was 15/15. Examination of the right eye showed a steamy, gray cornea, a moderate palpebral and bulbar conjunctival injection, and small pupil. The media and fundus were not seen, owing to the opacity of the cornea. There was a hypopyon, 2 mm. high, with a number of blood vessels leading from the sclera toward the

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\* From the Department of Ophthalmology, Stanford University Medical School.

<sup>1</sup> Fuchs, E. *Text-Book of Ophthalmology*, ed. 7. Philadelphia: J. B. Lippincott Company, 1923, pp. 98 and 718.

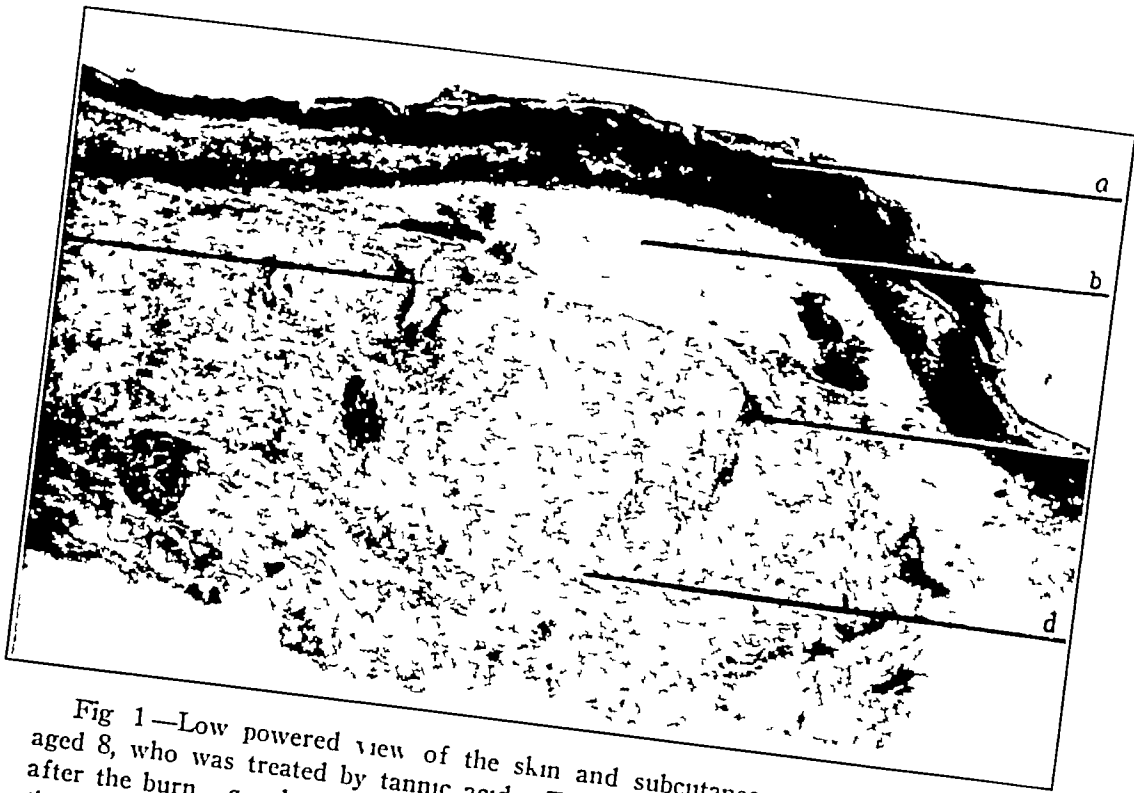


Fig 1—Low powered view of the skin and subcutaneous tissue in a child, aged 8, who was treated by tannic acid. The sections were removed four days after the burn. *a* indicates the tannic acid membrane, *b*, the separation zone, *c*, the hair follicle and *d* the subcutaneous connective tissue (From Ann Surg, July, 1926)

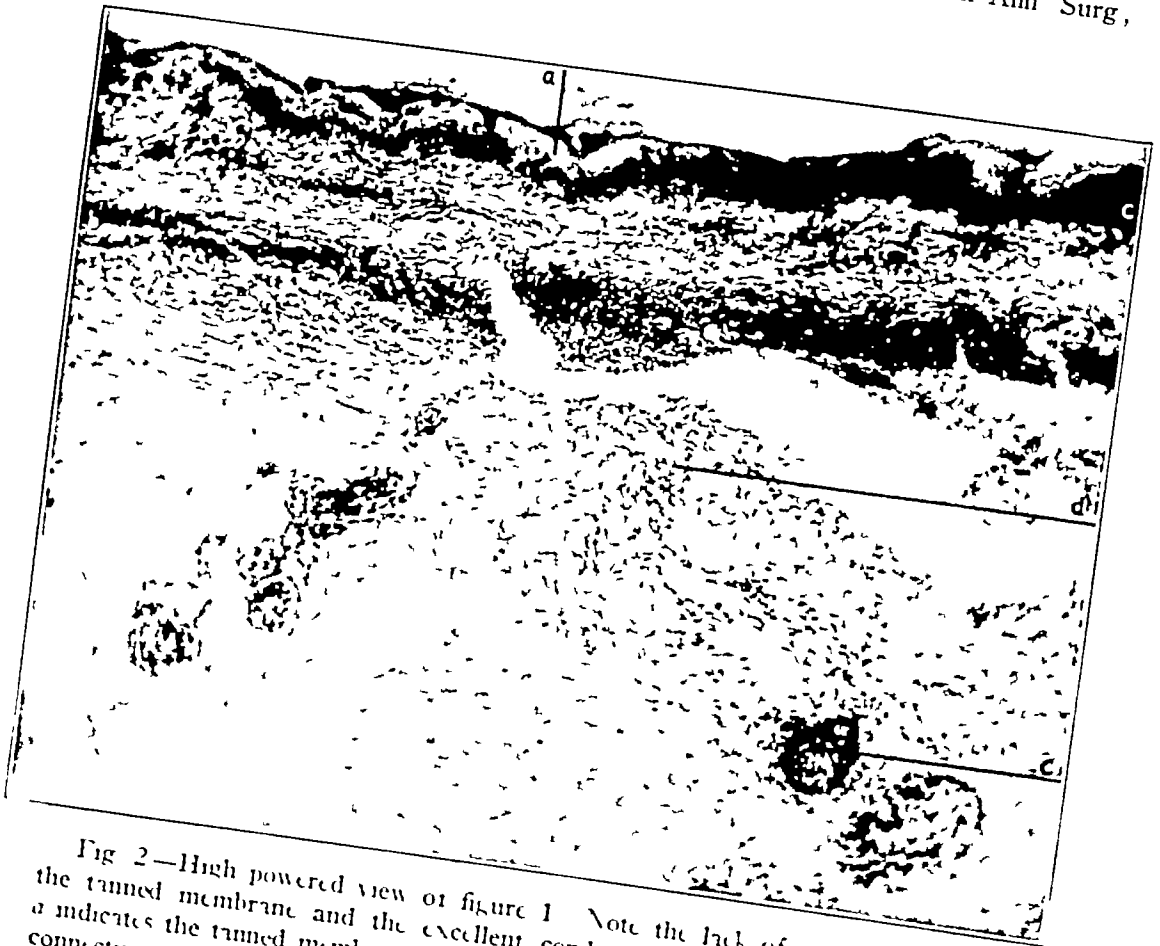


Fig 2—High powered view of figure 1. Note the lack of infection beneath the tanned membrane and the excellent condition of the subcutaneous tissue. *a* indicates the tanned membrane, *b*, the junction between the membrane and the connective tissue, *c* the hair follicles and *d* the subcutaneous connective tissue (From Ann Surg, July 1926)



spinal fluid was drained off. Twenty cubic centimeters of saline solution was injected into the cisterna, followed by 35 cc of 0.25 of 1 per cent gentian violet. The gentian violet appeared at the lumbar needle in about ten minutes. During the foregoing procedure, the patient's pulse became rapid, weak and thready, but he recovered promptly.

The patient died during the night, fifty-three hours after his admission to the hospital, and six and one-half hours after the injection of gentian violet.

*Clinical Diagnosis*—The following clinical diagnosis was made: Metastatic ophthalmia, streptococcic meningitis.

*Anatomic Diagnosis*—The anatomic diagnosis was as follows: Subacute endocarditis of the aortic valves with valvular aneurysm, acute, streptococcic meningitis, streptococcic panophthalmitis, early carcinoma of the stomach, syphilis of the aorta, syphilis of the liver, syphilitic cirrhosis, fatty liver, hydrocele, emphysema, apical tuberculosis of the lungs, healed, mucopurulent bronchitis.

*Summary of Necropsy Record*—A necropsy was performed by Dr. Ophuls, and the following observations were made: The man was strongly built and moderately well nourished. There was marked cyanosis of the face and neck, the superficial lymph glands were not enlarged. Edema was not present. There was marked chemosis. The conjunctiva of the right eye was greatly congested and contained a small amount of pus. The cornea showed a ring-shaped infiltration with pus along the edge of the ring, the corneal surface did not show any visible defect.

The skull cap and the longitudinal sinus were normal. The meninges on the right side were congested, edematous and showed moderate infiltration with pus, especially beside the sagittal fissure and along the course of the large blood vessels. The pia mater at the base of the brain was intensely stained with gentian violet. The dye coloring covered the median side of the frontal lobes to the edge of the olfactory bulbs and had penetrated a short distance into the sylvian fissures, as shown in the illustration. It had stained the entire base, including the pons, medulla and the median part of the lower surface of the cerebellum. The lower surface of the occipital lobes and the upper surface of the cerebellum were free. There was a slight purulent infiltration of the meninges over the lateral part of the cerebellum. The gentian violet appeared to be largely in the subarachnoid space. There was a small amount of the dye on the upper surface of the cerebellum near the posterior end of the fornix. Both lateral ventricles were intensely stained with the dye. The dura mater at the base of the brain from the region of the pituitary body to the rounding of the foramen magnum and also the anterior part of the tentorium were stained with gentian violet. The upper surface of the pituitary body was stained with the dye which did not penetrate into it. The proximal end of the sheaths of the ocular nerves was also stained with the dye. The gentian violet did not penetrate the orbits. Pus had not accumulated along the course of the optic nerves. The tissue of the orbits were free from infection.

The teeth of the lower jaw were in bad condition. The chest was large, deep and symmetrical. There were some old broken adhesions in the upper part of the pleura of both lungs. The left lung was diffusely emphysematous. There was a small superficial scar at the left apex. The bronchial tubes were dry, and those of the lower lobe contained a little mucopurulent material. The posterior part of the left lung was congested and edematous. A similar scar was found at the right apex, with a bullous emphysema. The congestion of the right base was more marked. The peribronchial lymph nodes were normal on both sides.

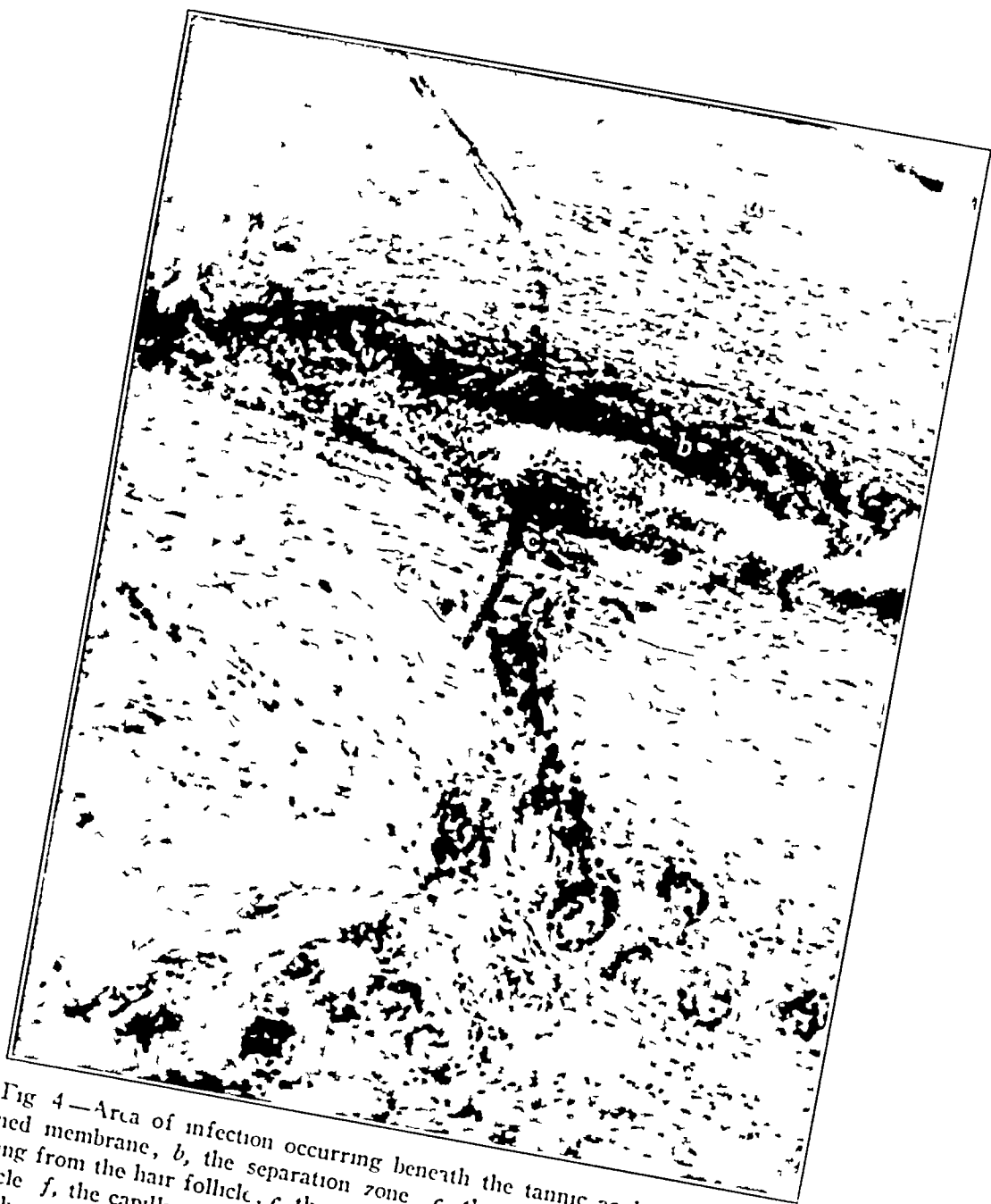


Fig 4—Area of infection occurring beneath the tannic acid *a* indicates the tanned membrane, *b*, the separation zone *c*, the irregular zone of epithelium arising from the hair follicle, *d*, the infection proceeding downward along the hair follicle *e*, the capillary filled with numerous polymorphonuclear leukocytes showing the gradual spread of infection

was separated by edema, and Bowman's membrane was ruptured and in places destroyed. The corneal tissues within this area were rather poorly stained or absent, especially in the deeper layers near Descemet's membrane which was still intact. Beneath the raised surface, near the limbus, the whole thickness of the cornea, especially just above Descemet's membrane, was densely infiltrated with round cells, forming a line of demarcation 2 mm from the limbus. There was a heavy deposit of fibrin, polymorphonuclears and pigment over the posterior surface of the cornea.

Examination of the uvea showed that the iris was poorly stained, with pyknosis and an occasional small hemorrhage near the root. The sphincter could not be seen and the pigment layer was gone. The ciliary body was engorged and full of hemorrhages and round cell infiltration its surface being covered by a heavy deposit of exudate, which in this region extended into the vitreous. The choroid was engorged and showed a beginning cellular infiltration which was more marked anteriorly.

The retina was still in situ, but there was an increasing amount of necrosis from the disk, where it appeared practically normal, toward the pars ciliaris. The anterior two-thirds of the retina was thin, atrophic and necrotic, and was covered by areas of exudate. The disk was normal except for slight edema. The lack of inflammatory changes in the posterior portion of the choroid and retina showed that the process was so virulent that necrosis was complete before there was any inflammatory reaction.

Bacteriologic. The slides stained by the Gram-Wiegert method showed considerable purulent exudate over the retina and choroid, and infiltrating the cornea. There were many groups of gram-positive diplococci, some in short chains, scattered through the exudate, especially in the region of the ciliary body and the anterior chamber.

Diagnosis. The diagnosis was Miasmatic endophthalmitis, septic, ring abscess of the cornea.

#### COMMENT

A case is reported in which a patient had subacute endocarditis of the aortic valves which was not diagnosed during life. The condition was complicated by an infection of the eye, later diagnosed as miasmatic ophthalmia, and by meningitis. Miasmatic ophthalmia due to ulcerative endocarditis is rare. According to (S)ier the following figures give the approximate estimate of the frequency with which different parts of the heart were affected in 200 cases of malignant endocarditis: aortic and mitral valves together, 41; aortic valves alone, 53; mitral valves alone, 27, tricuspid 19; the pulmonary valves 15 and the walls of the heart, 33. Acute suppurative meningitis was encountered in five of the twenty-three Miasmatic cases and in over 10 per cent of the 200 cases involved in the literature.

The causative organism streptococcus was found during life in the commingled spinal fluid in complicated streptococcal occurring in long and short chains and as diplococci. A blood culture showed growth of hemolytic streptococci. Bacteriologic examination of the

disturbances, such as vomiting and diarrhea. Frequent hypodermoclysis will give them relief from the gastro-intestinal symptoms. Clinically these cases resemble neither a staphylococcus nor a streptococcus type of infection, but they somewhat resemble a subacute type of gas bacillus infection. During our early experience with burns, a few of these patients died because we did not recognize the necessity of treating the infection beneath the tanned membrane. On studying sections taken from this membrane, we found infiltration of the fat and subcuticular layers with polymorphonuclear leukocytes (fig 4). After this experience, we decided to treat the patients for the infection and not for the burns. At present when a patient has a high temperature and there is

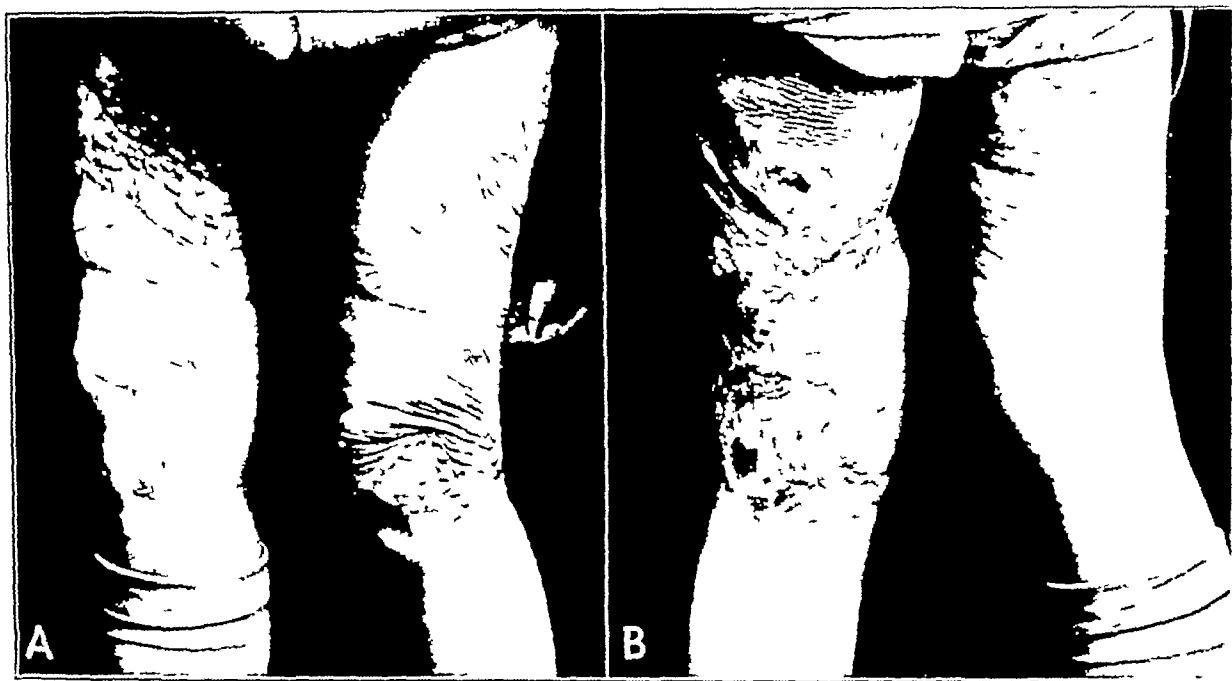


Fig 6—A is the anterior view of the patient in case 1, one year after leaving the hospital. It shows complete extension with no contractures, the result of numerous pinch grafts and the repeated manual extension of the knee joint. B is the posterior view of the same patient.

redness about the periphery and tenderness beneath the membrane it is our custom to anesthetize him and to excise the membrane as far as possible. Wet dressings are then applied to the granulating area. At first hot boric acid dressings were used. We found that crusts continued to form and that the granulations became infected and exuberant. The epithelization was much delayed.

Bennett, Blackfoot and Browning<sup>2</sup> advised treating these patients with a 1:5000 acriflavine. We adopted this method and have

<sup>2</sup> Bennett, Blackfoot and Browning. *Brit. M. J.* 2:306 (Aug. 19) 1922.

was separated by edema, and Bowman's membrane was ruptured and in places destroyed. The corneal tissues within this area were either poorly stained or absent, especially in the deeper layers near Descemet's membrane which was still intact. Beneath the raised surface, near the limbus the whole thickness of the cornea, especially just above Descemet's membrane, was densely infiltrated with round cells, forming a line or demarcation 2 mm from the limbus. There was a heavy deposit of fibrin, polymorphonuclears and pigment over the posterior surface of the cornea.

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#### COMMENT

A case is reported in which a patient had subacute endocarditis of the aortic valves which was not diagnosed during life. The condition was complicated by an infection of the eye, later diagnosed as metastatic endophthalmitis, and by meningitis. According to (3) the following figures give the approximate estimate of the frequency with which different parts of the heart were affected in 200 cases of malignant endocarditis: aortic and mitral valves together, 41; aortic valves alone, 53; mitral valves alone, 27; tricuspid 19; the pulmonary valves 15; and the walls of the heart, 33. Acute suppurative meningitis was encountered in any of the twenty-three Mönckeid cases and in over 10 per cent of the 200 cases involved in the literature.

The causative organism, streptococcus, was found growing here in a continuing thread and found as single and streptococci in the top and short stems and as single cocci in the long stems.

felt it to be of great value. The dressings are loosely applied and kept saturated with the solution. The granulations beneath it are red and clean, and epithelization occurs rapidly. We have been unable to detect any evidence of toxic absorption from the solution (fig 5). In a previous communication (figs 1, 2 and 3) we have shown that the islands of epithelization that occur beneath the membrane arise from the hair follicles. If infection can be prevented or diminished, this epithelization occurs so rapidly that the necessity for skin grafting has been gradually diminished.

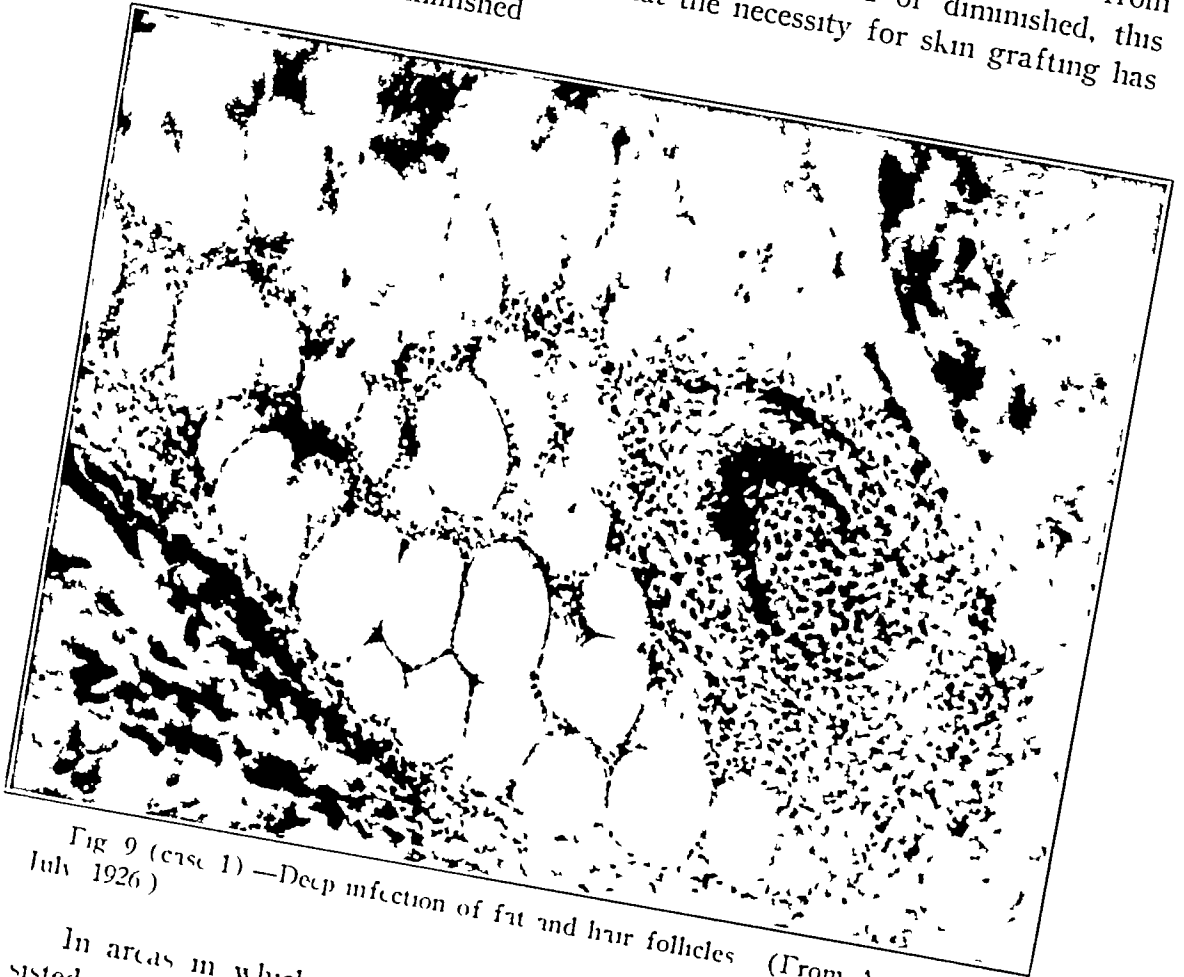


Fig 9 (case 1) —Deep infection of fat and hair follicles (From Ann Surg, July 1926)

In areas in which infection of the granulating surfaces has persisted for a considerable time many failures in grafting the skin occur. One may assume that so-called exuberant granulation tissue is due to a low grade infection. If this persists scar tissue forms beneath the superficial granulations. As the scar tissue contracts the circulation is gradually interfered with so that unless the entire scar tissue area is removed skin grafts will not derive sufficient blood supply to persist. If a curet is applied to this area granulations are scraped off leaving the scar tissue base and future results (figs 13 14 15 16 17 18 19 and 20)

# LIVING SLICK GRAYS IN THE REPAIR OF FRACTURES AND DISLOCATIONS \*

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The use of transplants of tascia lata in the repair of defects in the soft parts, as advocated by Gallic and Le Mesurier, has created a widespread interest in the use of living tissue as suture material. Many surgical conditions, especially recurrent and large direct hernia are now satisfactorily dealt with by this method. Massive grafts had been used before and reconstruction of tendons accomplished, however, marked general use of the material had not come into vogue before the experimental and detailed clinical work of Gallic and Le Mesurier became known. There are now frequent reports on the use of this material for the correction of recurrent dislocations and repair of ligaments. A simple method for using massive transplants of tascia lata in the repair of certain acute lesions of the bone and joint is described here. (3-good and probably have shown that tendons passed through drill holes in bone rapidly become firmly attached to the bone and form a solid living ligament. It has also been demonstrated that tascia will become adherent to tascia and that these transplants have to take over the function for which they are intended. The tensile strength of the material is greater than one might expect, and though it varies somewhat, depending on the person from whom it is taken it can be relied on in certain widths to maintain its position under the necessary strain on it to a degree that equals in efficiency any of the middle materials in common use.

## TECHNIQUE OF THE STRIKINGLY EFFECTIVE METHOD

This condition is apparently rare, only five cases having been observed in a period of eight years. It is usually produced by a fall striking on the point of the shoulder. Four of the five cases have occurred in young males. The lesion is characterized by an indefinite prominence over the inner end of the clavicle which becomes more marked on abduction and extension of the arm than the ordinary recent bony expansion. When the arm is lowered to the side the arm is often bent and the patient complains of pain on movement. This material is associated with a definite tenderness to the touch. The material is usually about 1/2 inch in diameter and 1/4 inch in length. It is usually found in the soft tissue of the shoulder joint. The material is usually found in the soft tissue of the shoulder joint. The material is usually found in the soft tissue of the shoulder joint.

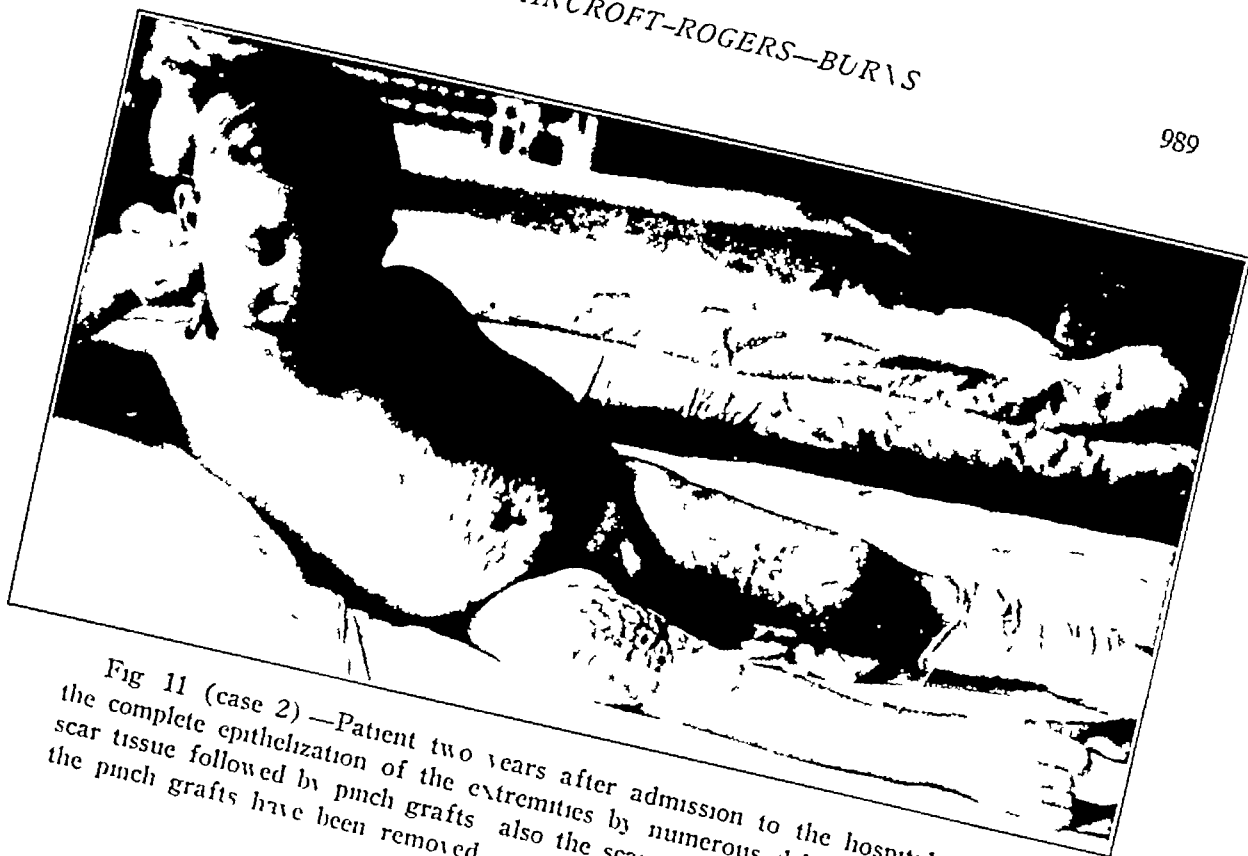


Fig 11 (case 2) —Patient two years after admission to the hospital. Note the complete epithelization of the extremities by numerous debridements of the scar tissue followed by pinch grafts. Also the scars of the abdomen from which the pinch grafts have been removed.

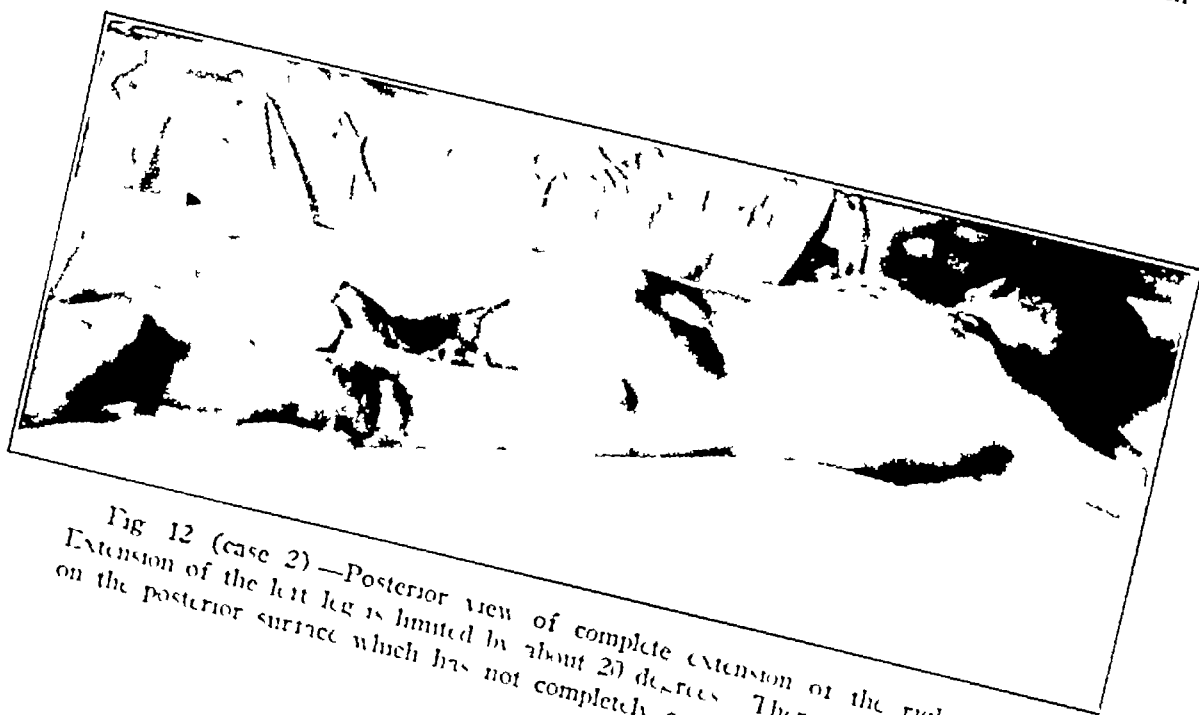
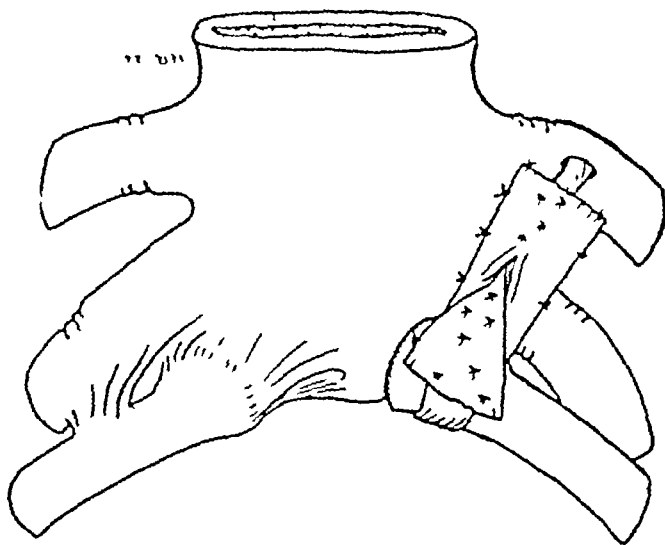


Fig 12 (case 2) —Posterior view of complete extension of the right leg. Extension of the left leg is limited by about 20 degrees. There is still an area on the posterior surface which has not completely epithelized.



exposed, due to its depth and to the great vessels underlying it. In two of these cases, occurring in boys aged 15 and 16, the second rib was found to be suitably deep anteroposteriorly, and easily accessible. The clavicle was drilled vertically just lateral to the articular surface with a 3 mm drill and the second rib fenestrated just lateral to the costal cartilage from front to back. A silver probe was passed through these drill holes, followed by a strand of strong silk to which was attached a strip of fascia lata 2 cm in width and 20 cm in length (fig. 1). The ends of the fascia were then spread out and the lower portion fenestrated by a longitudinal slit, about 1 cm in length, placed approximately 5 cm from the end. The upper portion of the fascia was passed through this slit, the clavicle engaged into its articulation and



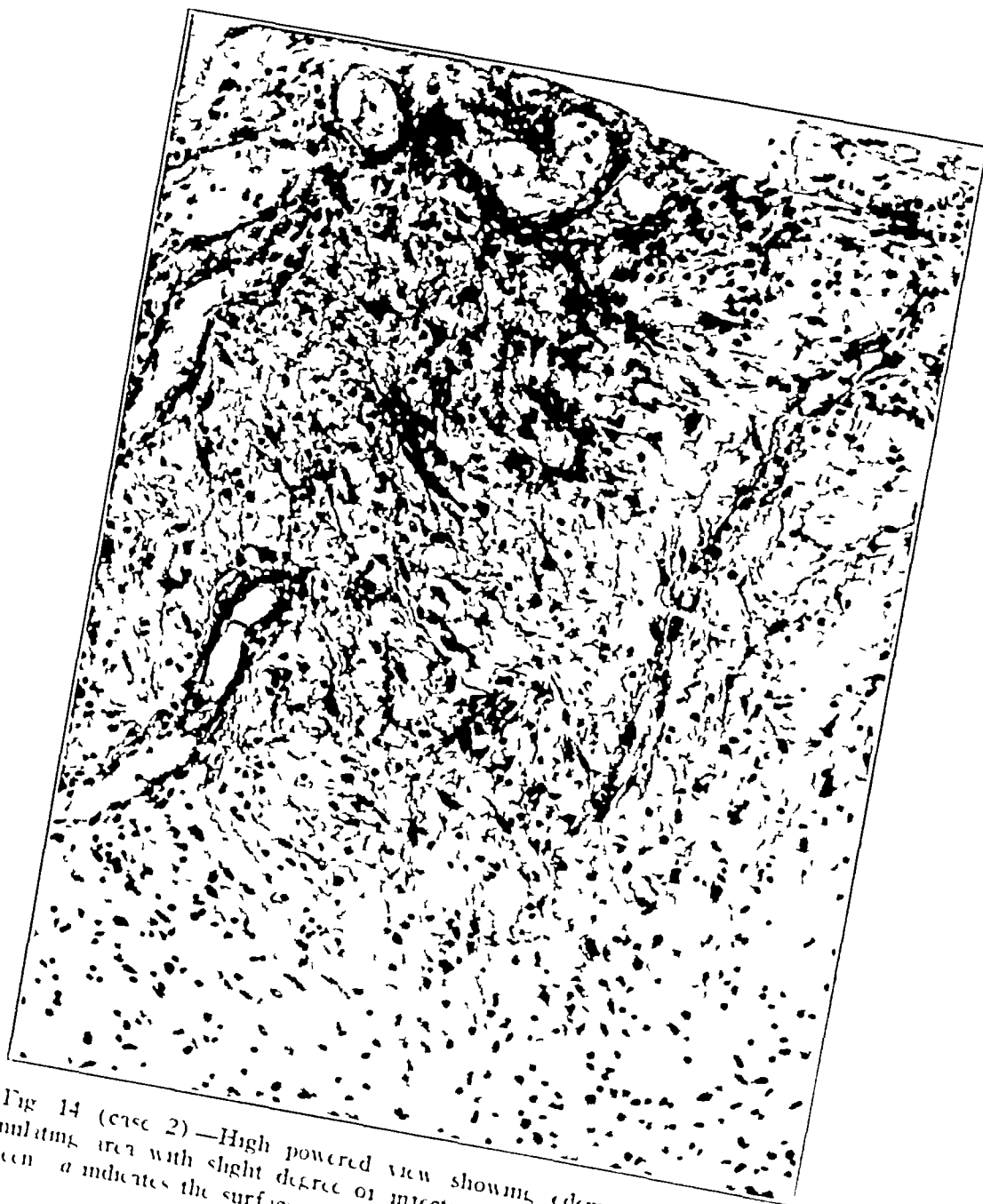


Fig 14 (case 2) —High powered view showing edema of the superficial granulating ulcer with slight degree of infection. Numerous blood vessels can be seen. a indicates the surface.

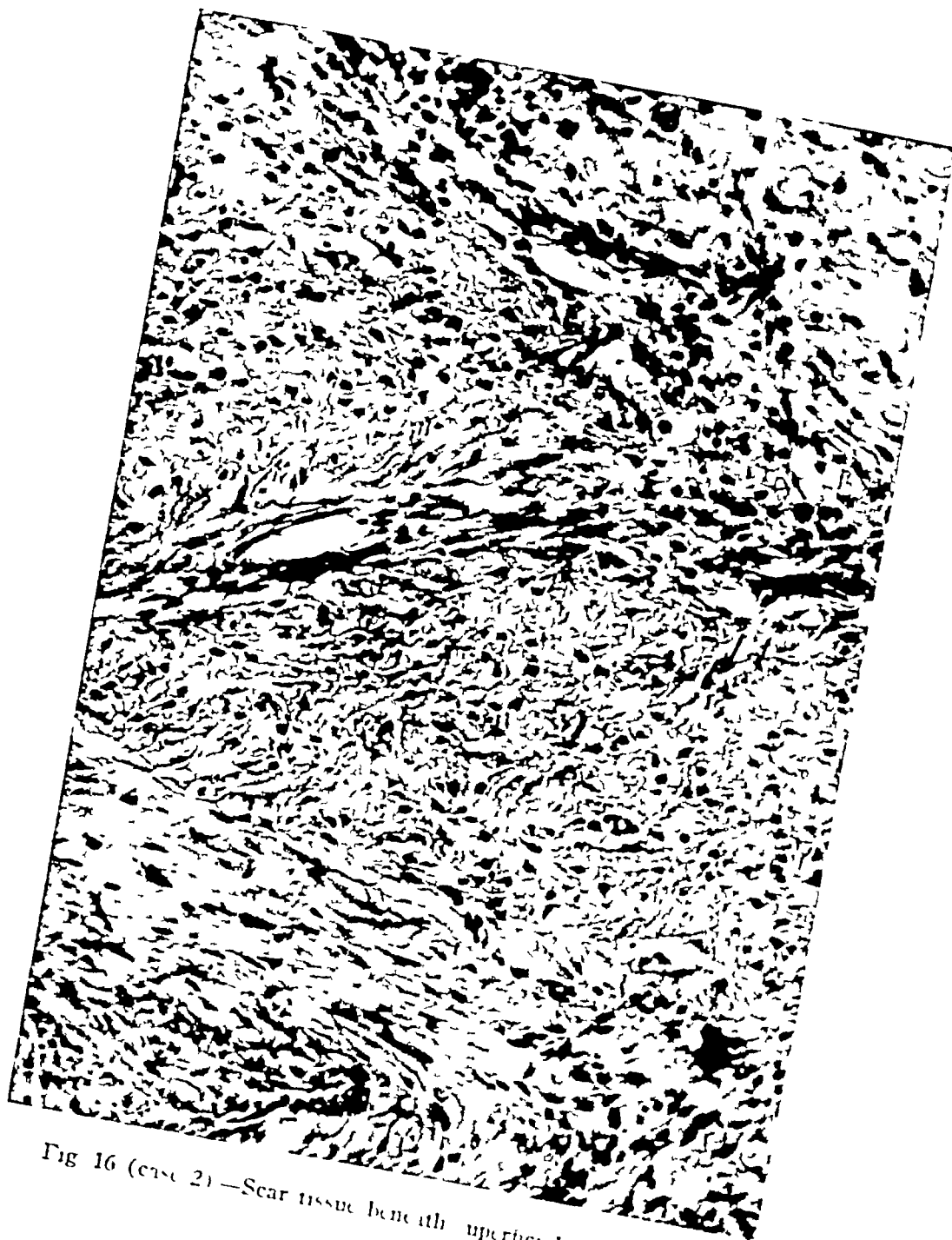


Fig. 16 (case 2) — Scar tissue beneath superficial granulations

infection and had grafted them early, the patient's period of hospitalization and disability would have been greatly diminished

These two cases are presented as contrasts. The child in case 1 was treated primarily by debridement—an inferior method—but skin was immediately grafted and the contractures were repaired following the

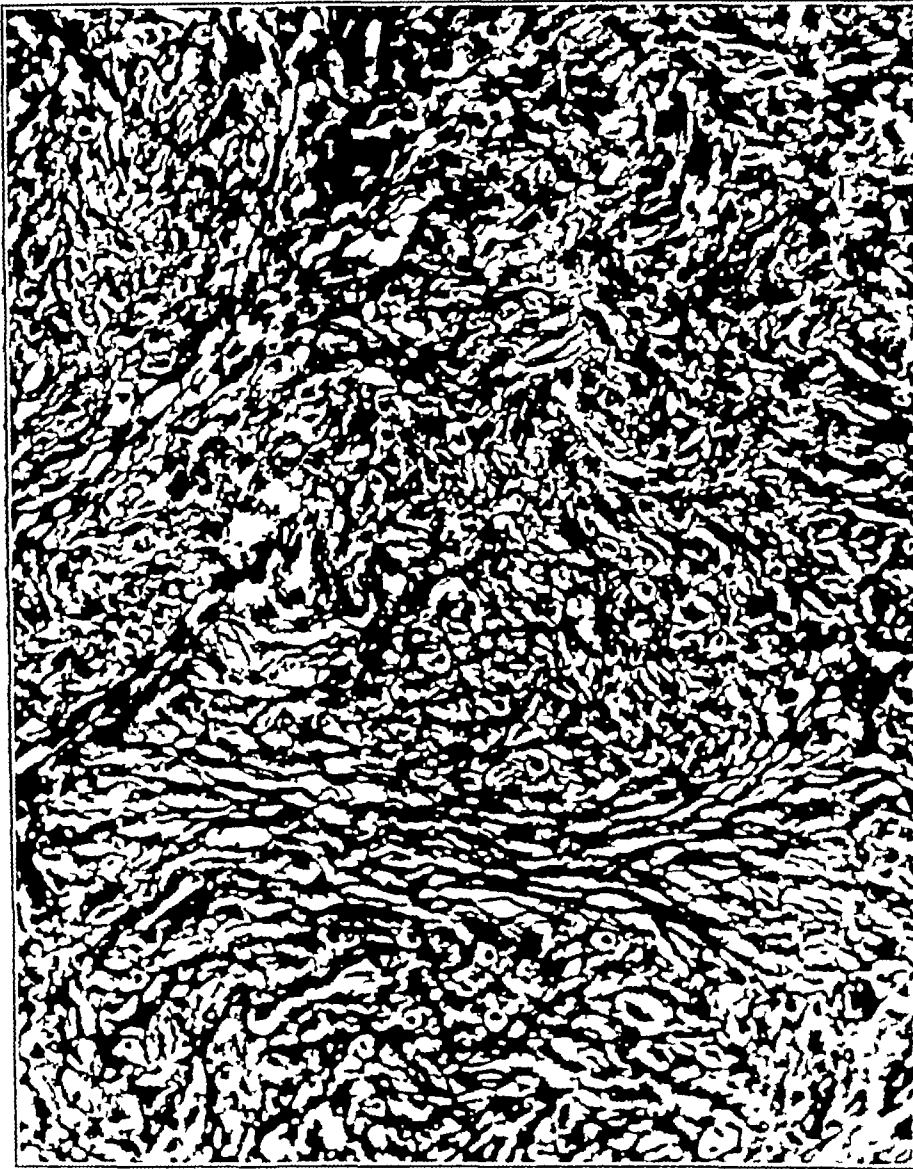


Fig. 17 (case 2) —Dense scar tissue in the region of the deeper area

epithelization. The child in case 2 was treated by tannic acid—a primarily satisfactory treatment—but in our attempt to prevent contractures the epithelization of the granulating areas was neglected and his period of hospitalization and deformity were greatly prolonged thereby.

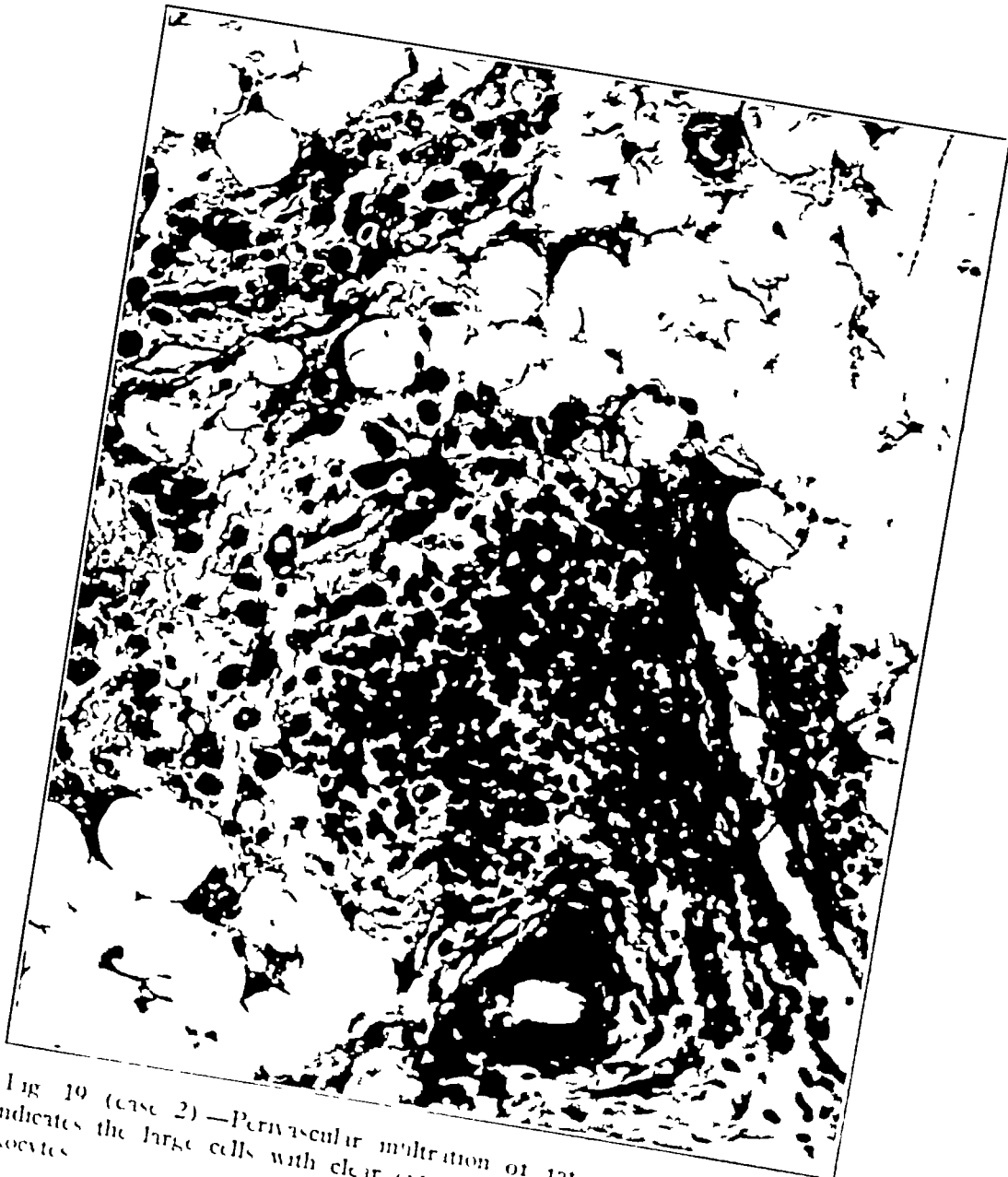


Fig. 10 (case 2) — Perivascular infiltration of rat with small round cells  
*a* indicates the large cells with clear cytoplasm and *b* the polymorphonuclear  
leukocytes.

CONCLUSIONS

- 1 Infection frequently occurs beneath the tanned membrane
- 2 If infection occurs, debride the eschar and treat the underlying cellulitis
- 3 Acriflavine 1/5,000, applied as a wet dressing, tends to diminish infection and apparently aids the epithelization
- 4 In deep third degree burns, it is advisable to apply skin grafts soon after the sloughs separate
- 5 When granulating areas have been infected and there has been a delay before grafting is attempted, it is advisable to excise the scar tissue down to the underlying fascia. Pinch grafts immediately applied are usually successful

hypopyon. The left eye was normal, with the exception of a nuclear cataract. The patient appeared more ill than could be explained by the condition of the eye. He was admitted to the hospital for observation and treatment.

The previous history was negative and a history of a present systemic complaint was not elicited. Physical examination showed that the teeth were in poor condition and that pyorrhea was present. The throat was clear, the neck showed pulsating vessels, but adenopathy was not found. The expansion of the chest was equal but poor. The heart did not show any increase in size, the apex was in the fifth intercostal space, 7 cm. from the midsternal line. The right border of cardiac dullness was not increased, and the supracardiac dullness was 6 cm. The sounds were distant but clear, and murmurs were not heard. The lungs were hyperresonant. There was bronchovesicular breathing, and coarse sonorous rales were heard throughout; there was no abnormal dullness, and moist rales were not heard.

Examination of the abdomen revealed dullness of the liver from the fourth right costal space to the umbilicus. The liver was smooth, and a nontender edge was readily felt 12 cm. below the right costal margin in the right midclavicular line. The spleen and kidneys were not felt. Tenderness or evidence of fluid was not found. The knee jerks were sluggish, and the ankle jerks were not obtained. The blood vessels were thickened; the radials were equal, synchronous and regular. The blood pressure was 92 systolic and 38 diastolic. The temperature was 39.2 C (102.8 F), the pulse rate 100, and respiration, 24. The white blood cells numbered 10,050, polymorphonuclears 80 per cent and lymphocytes 20 per cent.

*Treatment and Course.*—The patient received 15 cc. of milk parenterally. The next morning he said that his eye felt better. The cornea was duller and yellowish. There was a yellow ring on the posterior surface of the cornea a few millimeters from the limbus, giving the appearance of a ring abscess. The hypopyon was of the same height, but the eyeball was intensely injected. The temperature varied between 37.2 and 38.2 C (99 to 100 F). The pulse rate and respiration were normal. The white blood cells numbered 23,700, polymorphonuclears 93 per cent, and lymphocytes, 7 per cent. The patient felt chilly.

On the following morning, marked chills developed, the patient trembled and was irrational. There was marked rigidity of the extremities with occasional complete relaxation and a great deal of muscular twitching. All the deep reflexes were present and equal. Kernig's and Brudzinski's signs were positive. There was also involuntary passage of urine. The rectal temperature varied between 40.2 and 40.8 C (104.3 and 105.4 F), pulse rate, from 88 to 100 and respiration from 20 to 28. The blood pressure was 138 systolic and 70 diastolic. The white blood cells numbered 14,900, polymorphonuclears, 92 per cent and lymphocytes 8 per cent.

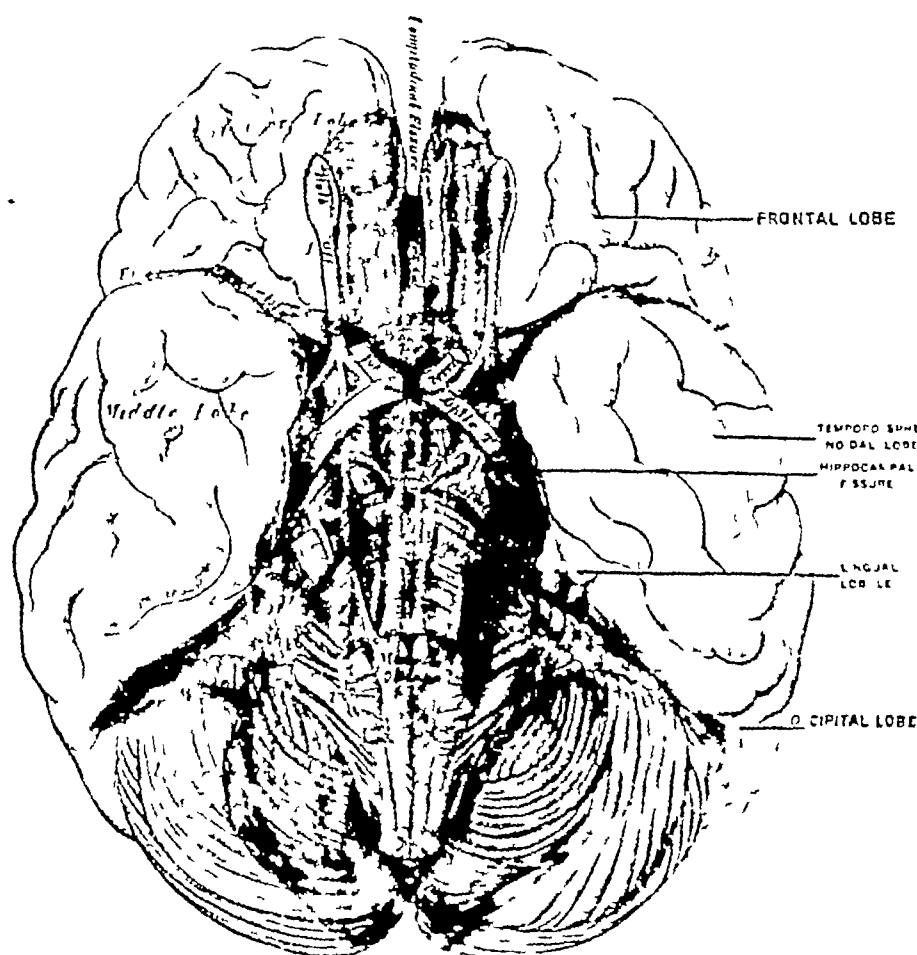
Within twenty-four hours the bulbar conjunctiva became edematous and the eye was bulging. There was little to be seen of the cornea. The diagnosis of meningitis and panophthalmitis (metastatic ophthalmia) was made.

A spinal puncture was performed with the following results: pressure 39 cm., cells, 98; leukocytes 98. Nonne test — — — Nonchitt test — — — The Wassermann reaction of the blood and spinal fluid was negative; uric acid was negative.

Smears of centrifuged spinal fluid stained with methylene blue showed many encapsulated streptococci occurring in long and short chains and as diplococci. There were many pus cells. A blood culture showed a growth of penicillin streptococci.

A lumbar puncture was repeated twelve days later and the following results were obtained: A second culture was positive for streptococci.

About 50 cc. of clear fluid was found in the pericardium. The heart was small and the heart muscle was soft and flabby. The heart valves were normal except the aortic cusps. Two of these showed slight roughness along the edge. The third one showed destruction at the base with the development of a valvular aneurysm about 2 cm. in diameter which had perforated. The opening of the perforation measured about 1 cm. The base of the aorta showed marked scarring and was distinctly and irregularly dilated. The coronary arteries were normal. The heart muscles on the right side averaged 2 mm., on the left 10 mm. Scars or areas of degeneration were not visible.



Base of the Brain

Fig. 1—Diagrammatic presentation of the distribution of gentian violet solution staining the base of the brain.

The spleen was large, measuring 16 by 12.5 by 4.5 cm. The capsule was slightly thickened and the splenic tissue was dark red and soft. The kidneys showed some edema of the perirenal tissue and a few scars in the cortex. They measured 13 by 6 by 3.5 cm. and were congested and edematous. The testes and seminal vesicles were normal; the prostate was small. The rectum contained much pus but otherwise was normal.

The stomach contained some undigested food. A tumor was found 3 cm. from the cardia, 10 cm. from the pylorus, and 10 cm. from the greater curvature.



5 cm in its largest diameter. The regional lymph nodes were not involved. The pancreas was normal. The liver projected three fingerbreadths in the right midclavicular line and was irregularly and deeply lobulated, it measured 28 by 23 by 8 cm. The capsule on the convexity was irregularly thickened and the liver tissue was nodular. The cut surface was slightly nodular. There were a few visible strands of fibrous tissue and some large scars at the base of the coarser lobulations. The gallbladder and contents were normal. The mesentery of the sigmoid flexure was cicatrized and contracted.

In the thoracic lumbar aorta, there was a moderate number of yellowish atheromatous plaques, there was also some scarring at the beginning of the aorta. The marrow of a rib was plentiful and soft. The tunica vaginalis of the right testis was filled with clear fluid and distinctly thickened. The testes showed moderate atrophy.

*Histologic Examination*—Examination of the aorta showed marked irregular fibrous thickening of the intima with fatty degeneration, necrosis and calcification encroaching somewhat on the media. There was old diffuse fibrosis of the vasa media, marked fibrous thickening of the adventitia with endarteritis of the vasa vasorum and moderate round cell infiltration about them. The mucous membrane of the stomach showed marked atrophy. In the liver there were some irregular strands of new fibrous tissue with moderate round cell infiltration, also moderate fatty infiltration. The rest of the liver tissue was normal. The pulp of the spleen was extremely congested, the arteries were normal. The lungs showed moderate emphysema and marked congestion. A smear of the marrow showed many polymorphonuclear leukocytes, otherwise, apparently it was normal.

*Bacteriologic Examination*—There were many red cells in the aortic cusps, few leukocytes and many gram-positive diplococci and streptococci in short chains. Many leukocytes and rather long chains of delicate gram-positive diplococci were seen in the meninges. Examination of the conjunctiva showed many epithelial cells and leukocytes, but bacteria were not present. Neither leukocytes nor bacteria were found in the orbital fat. The spleen showed many leukocytes, but no bacteria.

*Examination of the Eyeball*—Macroscopic. The eye was hardened in a solution of formaldehyde. The vitreous contained a large amount of yellowish pus. The lens lay free against the vitreous with a black pigmented ring on its anterior capsule. There was pus in the anterior chamber. The cornea was opaque, thickened and yellowish, and the posterior surface had a depression 3 mm wide and 3 mm from the limbus, forming a ring abscess. The central part of this surface, about 4 mm in diameter, was also depressed and flat. Between this central depression and the ring abscess the corneal surface was covered with linear striations. The anterior surface of the cornea was smooth, opaque and yellowish white. The ring abscess viewed from the anterior surface appeared as a dirty yellow ring. Adhesions were not found between the iris and the cornea, nor between the iris and the lens. The retina, sclera and ciliary body were easily separated from the choroid. The sclera was normal in appearance and separated freely from the conjunctiva. The optic nerve, 4 mm long, did not show any abnormality, and its sheath was normal.

*Histologic*—Histologic sections of the eyeball were stained by the hematoxylin-cosin method and examined by Dr Swett. There was a marked chemosis at the limbus with arcs of round cell infiltration and multiple small hemorrhages. The cornea was swollen and except for a small margin near the limbus, showed an absence of epithelium. There was a raised area about 1 mm wide and approximately 3 mm inside the limbus in which the stroma of the substantia propria

aortic cusps, at necropsy, showed many gram-positive diplococci and streptococci in short chains, of the meninges, many rather long chains of delicate gram-positive diplococci, and of the eye, many groups of gram-positive diplococci, some in short chains.

Just what the injury to the right eye, which the patient received five years before, and the recurrent inflammations had to do with the present infection is hard to say, except that it offers a hypothesis that an eye previously injured and subject to inflammations was more susceptible to an endogenous infection than it would have been otherwise.

In addition to the unusual conditions found at necropsy, there was the extensive staining obtained by the injection of 35 cc of 0.25 of 1 per cent gentian violet into the cisterna magna. The dye had stained the entire base of the brain, including the pons, the medulla and the median side of the frontal lobes to the edge of the olfactory bulbs and the median part of the lower surface of the cerebellum. The gentian violet appeared largely in the subarachnoid space. A small amount of the stain was found on the upper surface of the cerebellum, near the posterior end of the fornx. The dura mater at the base of the brain from the region of the pituitary body to the roundings of the foramen magnum and also the anterior part of the tentorium were stained with the gentian violet. The upper surface of the pituitary body was stained with the dye which did not penetrate into it. The proximal end of the sheaths of the ocular nerve was also stained. The gentian violet did not penetrate the orbit.

#### SUMMARY

A case of metastatic ophthalmia and meningitis of streptococcal origin, with complications of subacute endocarditis is presented, in which diagnosis of the endocarditis was not made during life. The causative organism, the streptococcus, was found during life in the spinal fluid and in a blood culture and at necropsy in the aortic cusps, the meninges and the eye. Gentian violet, which was injected into the cisterna magna six and one-half hours before the patient's death, was found to have stained the base of the brain extensively a great deal of it appearing in the subarachnoid space.

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Long periods of fixation with the arms to the side (three months in one case) did not result in a permanent reduction, the luxation taking place on the first attempt at abduction of the arm. There are some luxations of the sternoclavicular articulation that do not result in recurrent or permanent deformities. Posterior dislocation has been observed in the case of a school boy, aged 16. The tendency to upward displacement after reduction was not noted as in the other cases. Dr William Darrach has called my attention to certain upward dislocations that have healed spontaneously, and suggests, in explanation, the possibility of a rupture of the rhomboid ligament in the cases in which recurrent luxations take place. This is probably what occurs, although in the patients operated on so far we have neglected to examine this

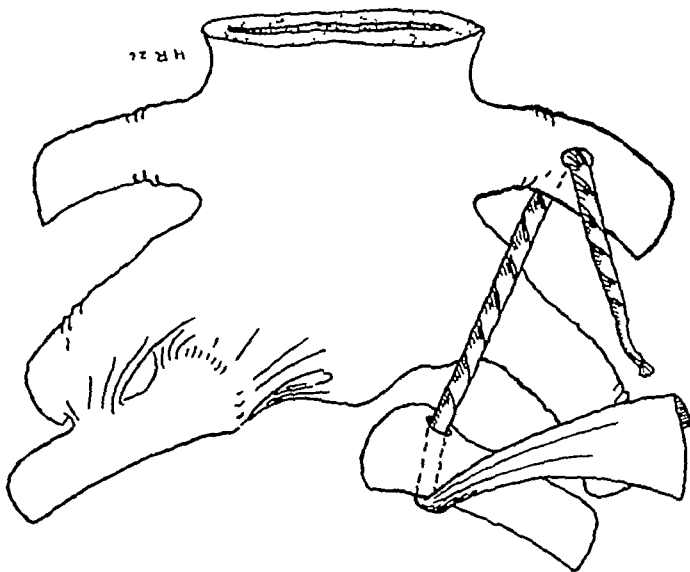


Fig. 1—Diagrammatic representation of the luxated sternal articulation of the clavicle. The inner end of the clavicle has been drilled vertically and the second rib anteroposteriorly. The fascial graft has been passed through. The method is advocated in children and adults of short stature. The graft was 2 cm by 20 cm, the drill, 3 mm.

ligament particularly. The impression has been gained at operation, however, that no ligamentous attachments in this region are intact. Darrach bases his theory on the proved rupture of the coracoclavicular and conoid ligaments in certain dislocations of the outer end of the clavicle and certain fractures through the outer 3 cm of this bone. In the recurrent cases, we have felt that a repair is impractical without the introduction of some material for internal fixation. At first sight it seemed reasonable to suppose that a loop of wire or fascia lata might be placed around the inner end of the clavicle and the first rib. It was found, however, that this portion of the first rib could not be safely